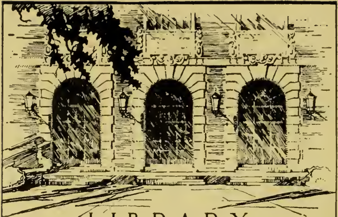

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BULLETIN NO. 36 **OCTOBER, 1900**

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

ANNOUNCEMENT TO NEW MEXICO RANCHMEN

AND LIST OF BULLETINS

By the Congressional Act of 1887, "the Hatch Act," a Department of Agricultural Colleges was endowed, having for its purpose *the performing of experiments of value to Agriculture and Horticulture and the diffusing of valuable information among the people.* The territorial Act of Feb. 28, 1889, which established the New Mexico College of Agriculture and Mechanic Arts, established also an Experiment Station in connection with the college. This department is in successful operation.

The character of the work so far done will be indicated by the subjoined list of bulletins published. It is expected that at least four bulletins will be published each year. Now that the college farm is at last equipped with livestock, it is believed that many of the future bulletins will be of much value to the stockmen of the territory.

The governing body of the Experiment Station desire to make it of the greatest possible use to the people of the territory and *welcome inquiries for information on agricultural topics and requests for the investigation of problems which meet ranchmen in the pursuit of their calling.* While the officers of the station may not always be able to give the desired information or to push the proposed investigation to an immediate and successful issue, they may be relied upon to do their best in every case: and in any event the Experiment Station will be found of much value to those who choose to avail themselves of its services as a *bureau of information* from which they may learn where they are most likely to obtain such information as this station is not itself prepared to supply. Visitors are always welcome at the Experiment Station.

So far as the funds of the institution and the time at the disposal of its officers will permit, the station will be glad to cooperate in every way possible in the establishment and maintenance of *Farmers' Institutes* and other means for the cultivation of interest in, and the diffusion of information upon, agricultural topics. It is hoped that the ranchmen of different regions of the territory will establish local institutes: and whenever possible one or more officers of the station will be sent to assist at their meetings.

Branch experiment stations are located at Roswell, Chaves county: Las Vegas, San Miguel county: and Aztec, San Juan county. These experiment farms were donated by the citizens of their respective localities to the territory. During the last session of the legislature provision was made for their support. The Roswell Station at the present time is the principal seat of our experiments in sub-drainage.

Any citizen of New Mexico who desires to receive all of our bulletins as published, may have his name put on our mailing list by sending his address to the Director. There is no charge for these bulletins. To persons outside of the territory, they will also be sent, so long as the edition printed holds out.

LIST OF BULLETINS PUBLISHED UP TO OCTOBER, 1900

The following bulletins have been issued from the Experiment Station, and, with the exception of those marked with an asterisk, will be sent free of charge to all persons in New Mexico who apply for them:

*No. 1, April, 1890—General Information.

*No. 2, October, 1890—Outline of Plans of Experimentation.

No. 3, June, 1891—Preliminary Account of Some Insects Injurious to Fruit—C. H. Tyler Townsend.

No. 4, March, 1892—Fruit Trees, Forest and Shade Trees, Nut-bearing Trees, and Vegetables—A. E. Blount.

No. 5, March, 1892—Notices of Importance Concerning Fruit Insects—C. H. Tyler Townsend.

No. 6, March, 1892—Cereals, Forage Plants, Grasses, Clovers, Textile Plants, and Sorghums—A. E. Blount.

No. 7, June, 1892—Scale Insects in New Mexico—C. H. Tyler Townsend.

*No. 8, November, 1892—Wheat, Oats, Barley, Rye, Sugar Beets, Sorghum, Canaigre, etc.—A. E. Blount.

No. 9, May, 1893—Insecticides and their Appliances—C. H. Tyler Townsend.

No. 10, September, 1893—Insects of 1893—T. D. A. Cockerell.

*No. 11, October, 1893—Notes on Canaigre and Meteorological Data—A. E. Blount and Harvey H. Griffin.

No. 12, November, 1893—The Value of Rio Grande Water for the Purpose of Irrigation—Arthur Goss.

No. 13, New Mexico Weeds, No. 1—E. O. Wooton.

No. 14, Çanaigre—A. E. Blount.

No. 15, Entomological Observations in 1894: Life Zones in New Mexico; Entomological Diary at Santa Fe—T. D. A. Cockerell.

No. 16, September, 1895—The Russian Thistle—E. O. Wooton.

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No. 17, December, 1895—Principles of Stock Feeding and Some New Mexico Feeding Stuffs—Arthur Goss.

No. 18, March, 1896—Some New Mexico Forage Plants—E. O. Wooton.

No. 19, April, 1896—Report of the Entomologist (Part I.)—T. D. A. Cockerell.

No. 20, December, 1896—Seeds—George Vestal.

No. 21, January, 1897—Results of Experiments at San Juan Sub-Station—H. H. Griffin.

No. 22, March, 1897—Alkali in the Rio Grande and Animas Valleys—Arthur Goss and H. H. Griffin.

No. 23, April, 1897—Sugar Beets—Cornelius T. Jordan.

*No. 24, August, 1897—Life Zones in New Mexico—T. D. A. Cockerell.

No. 25, February, 1898—Preliminary Notes on the Codling Moth—T. D. A. Cockerell.

No. 26, June, 1898—New Mexico Sugar Beets—Arthur Goss.

No. 27, June, 1898—Report on Plums—Geo. Vestal and Fabian Garcia.

No. 28, December, 1898—Life Zones in New Mexico, No. 2—T. D. A. Cockerell.

No. 29, May, 1899—New Mexico Sugar Beets—Arthur Goss and A. M. Holt.

No. 30, May, 1899—The Effect of Spring Frosts on the Peach Crop: With Cultural Notes on the Peach in New Mexico—Fabian Garcia.

No. 31, December, 1899—A Study of Soil Moisture—Charles A. Keffer and John D. Tinsley.

No. 32, December, 1899—Grasses and Forage Crops—Charles A. Keffer.

No. 33, April, 1900—Notes from the San Juan Sub-Station—Charles E. Mead.

No. 34, June, 1900—Principles of Water Analysis as Applied to New Mexico Waters—Arthur Goss.

No. 35, October, 1900—Observations on Insects—T. D. A. Cockerell.

No. 36, October, 1900—Announcement to New Mexico Ranchmen and List of Bulletins.

Inquiries intended for the *Entomologist* should be addressed to *T. D. A. Cockerell, East Las Vegas, N. M.* All other inquiries may be addressed to the DIRECTOR,

FREDERIC W. SANDERS,
Mesilla Park, N. M.

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BULLETIN NO. 36
(REVISED)
JULY, 1927

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION
State College, N. M.

Announcement to New Mexico Farmers and Stockmen and List of Station Publications

By Fabian Garcia

New Mexico Agricultural Experiment Station

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[1] In cooperation with the Office of Public Roads and Rural Engineering, United States Department of Agriculture.

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[5] Superintendent of the Acclimatization Field Station, operated by the United States Department of Agriculture, in cooperation with the New Mexico Agricultural Experiment Station.

[6] Bureau of Plant Industry, United States Department of Agriculture.

Announcement to New Mexico Farmers and Stockmen and List of Station Publications

By the Hatch Act, passed by Congress in 1887, a Department of Agricultural Colleges was endowed, having for its purpose the *performing of experiments of value to Agriculture, Horticulture, Animal Husbandry, and the diffusing of valuable information among the people.* The territorial act of February 28, 1889, which established the New Mexico College of Agriculture and Mechanic Arts, established also an Experiment Station in connection with the College. This division is in successful operation.

The character of the work so far done will be indicated by the subjoined list of Station publications. It is expected that at least four Station bulletins will be published each year. Now that the College farm and ranch are so well equipped with livestock, it is believed that many of the future bulletins will be of especial value to the stockmen, as well as the farmers, of the State. For the first time in its history, the Station now has adequate land and equipment with which to conduct range livestock investigations. Through the acquisition of control, during the spring of 1927, of about 96 sections of range land, the institution is also in a better position than formerly to carry on experimental work along the line of range improvement. The enactment of the Purnell Law in 1925 made available a material increase in Federal funds for investigations in agriculture and home economics. A considerable part of this increase is being used, in conjunction with State funds, for agricultural and horticultural experiments in sections of New Mexico where the climatic and soil conditions are somewhat different from those prevailing at State College. It is believed that the results thus obtained will be much more applicable to the local conditions.

The governing body of the Experiment Station desire to make it of the greatest possible use to the people of the State and *welcome inquiries for information on agricultural and livestock topics and requests for the investigation of problems with which farmers and stockmen meet in the pursuit of their calling.* While the officers of the Station may not always be able to give the desired information or to push the proposed investigation to an immediate and successful issue, they may be relied upon to do their best in every case; and in any event, the Experiment Station will be found of much value to those who choose to avail themselves of its services as a *bureau of information* from which they may learn where they are most likely to obtain such information as this Station is not itself prepared to supply. Visitors are always welcome at the Experiment Station.

The Station has been recording many data from its research and experimental work, which have been very helpful to the agricultural and livestock interests of the State. In the carrying on of an experimental or research problem the work must be done in a systematic way in order to obtain definite and reliable information; and for that reason all of it is conducted on what is known as the project basis. This means that before the work is undertaken the investigator must give the problem considerable thought, as to the facts that are to be worked out; the effect of the results upon agriculture; the time that will be required for the completion of the project; and he should also have an understanding of the influence that the varied environmental conditions surrounding the operations may have on the results obtained. Probably no other line of agricultural activity requires more painstaking and conscientious endeavor than working out new and detailed agricultural information. The individual must not only be conscientious and industrious, but he must be trained for the research to be undertaken.

The results of the experiments and investigations are fundamental in the development of the agricultural resources of any community or state; therefore, a great responsibility is placed upon the investigator. It is not always an easy matter to obtain quick results that will be of lasting benefit. The work naturally has to be slow, especially here in the Southwest, where there is such a variety of climatic conditions and such a difference in physical environment, as these factors have a great effect upon variation; particularly of plants. It is well known that the greater the difference in climate and in environment the more marked the variation is likely to be; because it is the nature of plants to vary, or, in other words, become adapted to new conditions. Those that do not adapt themselves to the new conditions must follow the law of the survival of the fittest—the unfit must die or disappear.

The results so far obtained at the Experiment Station have been recorded in the 163 Station and 533 press bulletins and in many other publications that have been issued from the Station.

At the present time there are over sixty experimental and research projects, from which valuable data are being obtained and which will be of material assistance to the agricultural and livestock interests.

It will be impossible to mention in this short bulletin the many ways in which the results of the different investigations will be of benefit. One thing that should always be taken into consideration, however, is the proper application of new agricultural information; if not properly applied, one may be badly disappointed. A person should bear in mind that *"Success in agriculture depends upon knowledge and the application of that knowledge to production.* Knowledge can be gained only through investigation."

The results obtained by these investigations form to a large degree the basis or foundation for agricultural instruction, either in the classroom by the instructors or out in the field among the farmers by lecturers and county agent workers. If new knowledge is not constantly being developed, the instruction soon becomes more or less out of date. These new facts, when properly interpreted and applied, are bound to play a part in the development of the agriculture of the State and be the means of making it more profitable.

In recent years, more effort has been devoted to the distribution of agricultural products than formerly, as it has become increasingly evident that the prosperity of the agricultural and livestock industries is involved to a very large degree, not only in improved methods of production, but in better marketing and distribution practices.

STATION ANNUAL REPORTS

First Annual Report.—1889-90.
Second Annual Report.—1890-91.
Third Annual Report.—1891-92.
Fourth Annual Report.—1892-93.
Fifth Annual Report.—1893-94.
Sixth Annual Report.—1894-95.
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Twenty-first Annual Report.—1909-10.
Twenty-second Annual Report.—1910-11.
Twenty-third Annual Report.—1911-12.
Twenty- fourth Annual Report.—1912-13.
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Twenty-sixth Annual Report.—1914-15.
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Twenty-ninth Annual Report.—1917-18.
Thirtieth Annual Report.—1918-19.
Thirty-first Annual Report.—1919-20.
Thirty-second Annual Report.—1920-21.
Thirty-third Annual Report.—1921-22.
Thirty-fourth Annual Report.—1922-23.
Thirty-fifth Annual Report.—1923-24.
Thirty-sixth Annual Report.—1924-25.
Thirty-seventh Annual Report.—1925-26.
Thirty-eighth Annual Report.—1926-27.

STATION BULLETINS

NUMBER

* 1. April, 1890.—General Information.
* 2. October, 1890.—Outline of Plans for Experimentation.
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* 34. April, 1900. Principles of Water Analysis as Applied to New Mexico Waters.—Arthur Goss.

* 35. October, 1900.—Observations on Insects.—T. D. A. Cockerell.

* 36. October, 1900.—Announcement to New Mexico Ranchmen and List of Bulletins.

* 37. March, 1901.—Notes on the Food of Birds.—T. D. A. Cockerell.

* 38. May, 1901.—Soil and Moisture Investigations for 1900.—J. D. Tinsley and J. J. Vernon.

* 39. June, 1901.—Orchard Notes.—Fabian Garcia.

* 40. November, 1901.—A Southern New Mexico Flower Garden.—F. E. Lester.

* 41. March, 1902.—Spraying Orchards for the Codling Moth.—Fabian Garcia.

* 42. April, 1902.—Alkali.—J. D. Tinsley.

* 43. June, 1902.—Drainage and Flooding for the Removal of Alkali.—J. D. Tinsley.
* 44. March, 1903.—Ash Analysis of Some New Mexico Plants.—Arthur Goss.
* 45. April, 1903.—Pumping for Irrigation from Wells.—J. J. Vernon and F. E. Lester.
* 46. May, 1905.—Soil Moisture Investigations for the Seasons of 1902 and 1903.—J. J. Vernon and J. D. Tinsley.
* 47. June, 1903.—Shade Trees and Other Ornamentals.— Fabian Garcia.
* 48. September, 1903.—Soil Moisture Investigations for the Season of 1903.—J. D. Tinsley and J. J. Vernon.
* 49. December, 1903.—Canaigre.—R. F. Hare.
* 50. February, 1904.—Steer and Lamb Feeding:—J. J. Vernon.
* 51. March, 1904.—Native Ornamental Plants of New Mexico.—E. O. Wooton.
  52. April, 1904.—Onion Culture. (In Spanish).—Fabian Garcia.
* 53. October, 1904.—Pumping for Irrigation.—J. J. Vernon, F. E. Lester, and H. C. McLallen.
* 54. March, 1905.—Soil Moisture Investigations for the Season of 1904.—J. D. Tinsley and J. J. Vernon.
* 55. June, 1905.—Tuberculosis in Cattle, and Tuberculin Tests of the Station Herd.—J. M. Scott.
* 56. November, 1905.—The Duty of Well Water and the Cost and Profit on Irrigated Crops in the Rio Grande Valley.—J. J. Vernon, A E. Lovett, and J. M. Scott.
* 57. January, 1906.—Steer Feeding.—J. J. Vernon and J. M. Scott.
* 58. April, 1906.—European Grapes.—Fabian Garcia.
  59. May, 1906.—Forty Years of Southern New Mexico Climate.—J. D. Tinsley.
  60. November, 1906.—Prickly Pear and Other Cacti as Food for Stock, II.—D. Griffiths and R. F. Hare.
  61. January, 1907.—Dry Farming in New Mexico.—J. J. Vernon.
* 62. February, 1907.—Pig Feeding.—J. J. Vernon and J. M. Scott.
* 63. March, 1907.—Melon Culture.—Fabian Garcia.

64. April, 1907.—Cactus Fruits as Human Food.—R. F. Hare.

65. May, 1907.—Band Record of the Codling Moth and Notes on Spraying.—Fabian Garcia.

* 66. April, 1908.—The Range Problem in New Mexico.—E. O. Wooton.

67. May, 1908.—Chile Culture.—Fabian Garcia.

68. August, 1908.—Injurious Insects.—Fabian Garcia.

69. September, 1908.—Digestibility of Prickly Pear by Cattle.—R. F. Hare.

* 70. April, 1909.—Sweet Potato Culture.—Fabian Garcia.

* 71. May, 1909.—Small Irrigation Pumping Plants.—B. P. Fleming.

* 72. August, 1909.—Production of Denatured Alcohol from Tunas and Other Sources.—R. F. Hare.

* 73. November, 1909.—Tests of Pumping Plants in New Mexico, 1908-1909.—B. P. Fleming and J. B. Stoneking.

* 74. January, 1910.—Onion Tests, 1905-09.—Fabian Garcia.

* 75. February, 1910.—Apple Culture.—Fabian Garcia.

76. March, 1911.—Peach Experiments, 1906-10.—Fabian Garcia and J. E. Mundell.

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78. May, 1911.—Cacti in New Mexico.—E. O. Wooton.

* 79. June, 1911.—Alfalfa and Corn for Fattening Lambs.—H. H. Simpson.

* 80. September, 1911.—A Study of the Carbohydrates in the Prickly Pear and its Fruits.—R. F. Hare.

* 81. December, 1911.—The Grasses and Grass-like Plants in New Mexico.—E. O. Wooton and P. C. Standley.

* 82. March, 1912.—Growing Denia Onion Seed.—Fabian Garcia.

* 83. June, 1912.—Composition of Some New Mexico Waters. —R. F. Hare and S. R. Mitchell.

* 84. November, 1912.—Wheat Growing Under Irrigation.—E. P. Humbert.

* 85. January, 1913.—Grape Crown Gall Investigations.—Fabian Garcia and J. W. Rigney.

* 86. April, 1913.—Soil Moisture.—E. P. Humbert and R. E. Willard.

* 87. June, 1913.—Trees and Shrubs of New Mexico.—E. O. Wooton.

* 88. October, 1913.—Preliminary Tank Experiments on the Movement, Changes in Composition, and Toxic Effects on Wheat of Certain Salts in the Sandy Loam and Adobe Soils.—R. F. Hare.

89. February, 1914.—The Hardiness of Fruit Buds and Flowers to Frost.—Fabian Garcia and J. W. Rigney.

* 90. May, 1914.—Alfalfa Pasture for Pigs.—Luther Foster and H. H. Simpson.

* 91. June, 1914.—The Utilization of Feed by Range Steers of Different Ages. I.—Alfalfa Hay.—F. W. Christensen and H. H. Simpson.

* 92. January, 1915.—Onions, Spinach, Cauliflower, and Casabas.—Fabian Garcia ond J. W. Rigney.

* 93. March, 1915.—Soil Physics and Soil Moisture in Relation to First Year's Growth of Alfalfa.—L. R. McNeely and G. W. Kable.

94. April, 1915.—The Grape Leaf Hopper.—D. E. Merrill.

95. April, 1915.—I. Probable Combination of Chlorine Ions in Alkali Salts. II. A Review and Discussion of Alkali in Soils.—R. F. Hare.

* 96. June, 1915.—Alfalfa Hay for Hogs.—Luther Foster and H. H. Simpson.

97. June, 1915.—Tests of Submerged Orifice Headgates for the Measurement of Irrigation Water.—F. L. Bixby.

* 98. June, 1915.—Economic Feeding for Milk Production in New Mexico.—R. W. Latta and Luther Foster.

99. November, 1915.—Peas as an Orchard Green Manure and Cover Crop.—Fabian Garcia.

100. January, 1916.—Winter Protection of the Vinifera Grape. —Fabian Garcia and J. W. Rigney.

101. March, 1916.—Feeding Range Steers.—Luther Foster and H. H. Simpson.

102. April, 1916.—Grasshopper Control.—D. E. Merrill.

103. June, 1916.—The Utilization of Feed by Range Steers of Different Ages. II. Alfalfa Hay and Milo Meal.—F. W. Christensen and Luther Foster.

104. February, 1917.—Dry Farming in Eastern New Mexico. J. E. Mundell and H. G. Smith.

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AGRICULTURAL EXPERIMENT STATION
MESILLA PARK, N. M.

NOTES ON THE FOOD OF BIRDS

BY

T. D. A. COCKERELL

The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others so far as the editions printed will allow.

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NOTES ON THE FOOD OF BIRDS

BY T. D. A. COCKERELL

The time has not yet come for a full survey of the feeding habits of New Mexico birds. Many more careful observations must be made and many more stomachs examined, before we can say definitely what each bird eats during every season of the year. The present notes may serve simply to draw attention to the subject; and if the readers of this bulletin will kindly make further observations in their several localities, and communicate them to us, they will be highly appreciated, and carefully credited when used.

The best information we have on the food of birds is contained in the publications of the Department of Agriculture. Dr. C. H. Merriam and his colleagues, of the Biological Survey, have collected a very large body of facts, and are still actively engaged in the investigation. The following publications of the Biological Survey are obtainable from the Department of Agriculture and are especially to be commended as giving full and exact information in a readable form:

F. E. L. Beal—Some common birds in their relation to Agriculture.

T. S. Palmer—Legislation for the protection of birds, other than game birds.

W. B. Barrows and E. A. Schwarz—The Common Crow of the United States.

T. S. Palmer—A review of Economic Ornithology in the United States. (Yearbook for 1899).

F. E. L. Beal—Preliminary report on the food of Woodpeckers.

F. E. L. Beal and S. D. Judd—Cuckoos and Shrikes in their relation to Agriculture.

F. E. L. Beal—Food of the Bobolink, Blackbirds and Grackles.

W. B. Barrows—The English Sparrow in North America.

All things considered, there cannot be the least doubt that birds do far more good than harm to Agriculture and Horticulture. We notice very readily such little destruction of our fruit or field crops as takes place, but we do not notice the everlasting destruction of injurious insects. We do not realize easily what would become of our crops if there were no birds; how many insects, but for this check, would increase so rapidly as to destroy every green thing in sight. But the purpose of this bulletin is not to pronounce a judicial opinion on the standing of all New Mexico birds, but simply to bring forward certain evidence which may be of interest and value.

THE HARM DONE BY BIRDS

Injurious Birds at Mesilla Park

Mr. Fabian Garcia has given me the following notes of his observations on the Experiment Station farm at Mesilla Park:

"I have observed that in the spring the cherries, especially the sweet varieties, are badly eaten up by the mocking bird and the sparrow. They eat and destroy about a third to half of the cherries on the trees. You understand, of course, that there are only a few trees; if there were large orchards, perhaps we could not notice the amount eaten by the birds.

"During summer and fall the blackbird and sparrow are extremely bad on kaffir corn and sorghum. They eat nearly all of the seed on the heads of both the kaffirs and sorghums. They are so bad that it is almost impossible for us here at the station to raise any kaffir corn seed. They begin to eat it as soon as it is formed. It may be that if large fields of these sorghums were planted all over the valley the damage done by these birds would not be noticeable. Doves are sometimes bothersome to early ripening wheat, but only to a limited extent and not every year."

The following important observations are by Mr. Birtwell of Albuquerque.

Sandhill crane eating corn

"This bird is a true pest in corn regions. It will travel straight through a field of eared corn, strip the ears of all in convenient reach, peck a few grains and pass beyond to the next."—F. J. Birtwell.

Canada goose injuring wheat

"*Anser canadensis* is fond of young wheat in irrigated fields."--F. J. Birtwell.

Long-crested jay and Woodhouse's jay eating corn

Mr. Birtwell saw these birds (*Cyanocitta stelleri macrolopha* and *Aphelocoma Woodhousei*) eating corn from horse feed.

House finch eating fruit buds

"This bird is exceedingly destructive to fruit orchards from the time of early budding to young fruit. I have watched dozens of these birds greedily devouring the stamens of apple blosoms, and birds shot while thus engaged have been found with the œsophagus crammed with filaments and anthers."—F. J. Birtwell.

The House finch *(Carpodacus mexicanus frontalis)* is the common little bird which nests under the eaves of houses in all our towns. It has been considered harmless, but Mr. Birtwell's observations will tend to take away its good character. It may be, however, that a reasonable destruction of flowers is beneficial, preventing overloading with fruit and doing away to some extent with the necessity of thinning out.

The English sparrow has recently found its way into New Mexico, and occurs at Raton and Las Vegas. It might be expected to supplant and drive out the house finch; but in Las Vegas, at any rate, the house finch is still abundant.

For an account of the English sparrow, see Bulletin 1, Division of Ornithology, U. S. Department of Agriculture.

Injury to fruit at Santa Fe

Mr. Arthur Boyle writes as follows concerning his experience of the last twenty years at Santa Fe:

"The worst birds amongst the cherries are the 'redpoll' and a bright colored green and yellow bird the name of which

I have not been able to find out. The cock bird is all bright yellow with black bars on the wings, a red head, a reddish breast; and the hen is all greenish yellow. (Evidently the Louisiana tanager, as Mr. E. Atkins suggested to me). This is a very bad bird on all the fruit. The bunting is another bad bird; it with the 'redpoll' eats the leaf and fruit buds of the trees, especially peach buds, and does a great deal of mischief in the earliest spring when the buds are just beginning to swell. Many other birds eat cherries, of course, but none do any appreciable damage except the above. I do not think that any birds ought to be systematically destroyed; all fruit eaters are insect-eaters, and their absence would be very quickly felt in the increased ravages of insect pests on all kinds of cultivated fruits, vegetables and flowers."

THE GOOD DONE BY BIRDS

Insects eaten

Red-backed Junco.—Stomachs of birds shot by Mr. E. Atkins on the upper Sapello River, N. M., contained beetles and scales of lepidoptera. In one case some seeds were found. The stomach of a bird from the Rio de las Casas contained small seeds and remains of insects.

Western Flycatcher.—One shot by Mr. E. Atkins on the upper Sapello River had remains of beetles in its stomach.

Audubon's Warber.—A bird shot by Mr. Atkins on the Rio de las Casas had in its stomach remains of beetles, and the head of a small green bee of the genus *Halictus*, apparently *Halictus ruidosensis*.

The above are fair samples of the results of the examination of the stomach-contents of various small birds. The number of insects eaten is immense, but they are not all injurious species. The little green bee (*Halictus*), for instance, is beneficial as a carrier of pollen, and does no harm.

Weed seeds eaten

Birds eat great numbers of seeds of weeds, and are considered therein beneficial, though they doubtless also aid in the distribution of various plants, some of which may be troublesome to agriculture.

Mr. F. E. L. Beal says: "The value of our native sparrows as weed destroyers is not appreciated. Weed seed forms an important item of the winter food of many of these birds, and it is impossible to estimate the immense numbers of noxious weeds which are thus annually destroyed."

Mr. Birtwell has observed the following birds at Albuquerque eating the seeds of sunflowers:

Arkansas Goldfinch *(Spinus psaltria)*.
Pine Siskin *(Spinus pinus)*.
Red-winged Blackbird *(Agelaius phœniceus)*.
Audubon's Warbler *(Dendroica auduboni)*.
House Finch *(Carpodacus)*.

The following birds have been seen by Mr. Birtwell to glean weed seed of various harmful kinds from fields in fall and winter:

Meadow Lark *(Sturnella)*.
Red-winged Blackbird *(Agelaius phœniceus)*.
Yellow-headed Blackbird *(Xanthocephalus xanthocephalus)*.
Intermediate Sparrow *(Zonotrichia leucophrys intermedia)*.
Desert Song Sparrow *(Melospiza fasciata fallax)*.
Oregon Junco *(Junco hyemalis oregonus)*.
Gray-headed Junco *(Junco caniceps)*.
Pink-sided Junco *(Junco annectens)*.
Red-backed Junco *(Junco phœonotus dorsalis)*.

And "in fact, the majority of our small wintering species."

Useful birds at Santa Fe

Mr. Arthur Boyle writes as follows:—"I have noticed all the birds that visit the garden busy chasing and eating grasshoppers at all times, particularly the young wingless hoppers; even the little wild canary, that is also so very fond of the fruit buds, will attack, kill and gobble some of a grasshopper nearly as big as itself if it is young and tender. One of the best friends of the fruit grower is the Rocky Mountain jay, the big dark blue jay with the black head and crest. They search the branches and bark of the trees for codling moth cocoons and are death on grubs. The jay, the woodpecker, sapsucker and all their tribe work all winter long and eat no end of grubs, larvæ and chrysalids. These should be protected by every means possible; in fact, I don't know any birds that ought not to be protected. I believe they all do a great deal more good than harm, although we don't always know it."

Bullock's oriole eating caterpillars

Mr. Emerson Atkins has observed these birds *(Icterus bullocki)* in the mountains near Las Vegas busily feeding on caterpillars *(Clisiocampa fragilis)*, which are clustered on the willows and wild plum trees, and which are so destructive to foliage on the Pecos Forest Reserve. This happened in the spring, when the work of the birds was most timely, and there can be no doubt that much good was done.

SOME MISCELLANEOUS NOTES

Birds flying long distances between meals

It must not always be assumed that the food found in a bird's stomach was eaten near the place where the bird was shot. Mr. Birtwell informs me that an American Merganser (*Merganser Americanus*) shot by Mr. W. H. Cobb at Albuquerque had in its stomach a piece of salt water sea-weed (*Fucus*) and salt-water perch partly digested. A gull shot near Las Vegas Oct. 22nd, 1900, had in its stomach many grasshoppers, which were identified by Mr. S. H. Scudder as *Encoptolophus*, probably *E. parvus*, and *Melanoplus compactus*. Although thirty-one species of *Melanoplus* have been collected in New Mexico, *M. compactus*, which is known from Dakota and Nebraska, has never been collected there.

Some years ago the writer found a new species of *Crustacea* in a warm spring near Socorro, N. M. This creature, which was described by Miss Harriet Richardson as *Sphæroma thermophilum*, belongs to a marine genus and family, and must undoubtedly have been derived originally from the sea, though it has been isolated long enough in the spring to have acquired specific distinctions. It is not possible to suppose it a relic of cretaceous time, when the sea washed over New Mexico, and therefore I conclude that in some way it must originally have been brought by some bird making a long flight from the sea, as the *Merganser* cited above. Just how the eggs or young of the crustacean were carried so far we cannot tell, but it is possible to imagine how it could have occurred.

Birds eating juniper cedar berries

Mr. Birtwell observed the following birds eating the berries of cedar *(Juniperus)* trees in the winter of 1899:

Western Robin *(Merula migratoria propinqua).*

Bluebird *(Sialia Mexicana).*

Townsend's Solitaire *(Myiadestes Townsendi).*

This winter (1900-1901) Mr. Birtwell says the trees are nearly barren, and the robins and bluebirds are absent.

In Wet Mountain Valley, Colorado, I examined the stomach of a Western Robin, and found it to contain berries of *Juniperus communis.*

THE WOODPECKERS

No birds are more conspicuous about our orchards and by our roadsides than the different kinds of woodpeckers. As questions are often asked regarding these birds, and farmers are often in doubt as to their utility or harmfulness, I have thought it useful to abstract the information which has been published regarding their food, adding such few remarks as my own observations suggest.

It may be said at once, that as a whole the woodpeckers are extremely useful and are entitled to protection as much as any birds that fly. Of all the species reported from New Mexico, only two may be considered injurious, and of these the red-headed woodpecker is too rare to be of importance, leaving only the red-naped sapsucker as a serious cause of loss.

The exact status of the red-naped sapsucker is not perfectly established. It is known that it devours quantities of injurious insects, and while the rows of holes it makes in the trunks of apple trees are familiar enough, it is not apparent that the ensuing damage is very great in our dry climate.

Dr. J. B. Smith has written thus of the injuries caused by woodpeckers in New Jersey: "Now comes another factor—the woodpecker and its allies, that make war upon the borers. They peck and hammer away at infested spots, and many a fat borer falls prey to their activity and industry; but whenever they haul out a specimen they leave a hole, and that is, too often, an entrance point for the water, that, after all, is as much to be dreaded in the tree as it is useful when it reaches the roots through the soil."

But in New Mexico these holes seem to heal up readily, though they may leave scars which would affect the value of the wood. Water is not so plentiful with us as in New Jersey, and the growth of harmful fungi is not so readily stimulated by an injury or perforation of the bark. Dr. Coues, than whom there is no more eminent authority, says of woodpeckers: "They dig insects and their larvæ out of trees, and are eminently beneficial to the agriculturist and fruit-grower. Contrary to a prevalent impression, their boring does not seem to injure fruit trees, which may be riddled with holes without harmful result."

Mr. F. J. Birtwell has noticed the red-naped sapsucker, Williamson's sapsucker and Baird's woodpecker, all feeding on the sap of apple trees in New Mexico, as he informs me in a letter. This would seem to convict the two latter birds, as well as the first mentioned, of injurious habits; but it is probable that they do little if any harm, and much good.

Prof. A. J. McClatchie has lately recorded that the Gila woodpecker devours the ripening dates in Salt River Valley, Arizona, and is thus quite destructive.

The Red-Naped Sapsucker

This bird is of medium size mottled with black and white. In the adult male, the crown of the head, and the throat, are bright crimson; behind the red of the throat is a large black patch, while the under parts behind this are dirty white, more or less marked with grey. In the female and young male the red on the head is very much reduced, and scarcely noticeable, while the under parts are more decidedly yellowish. The bird has four toes; and the tongue is scarcely extensile, the tip being obtuse and brushy. The specimens before me were collected by Mr. E. Atkins, on the Sapello River, on the Rio de las Casas, and at Cleveland, all in New Mexico. The bird was apparently first collected in New Mexico by Dr. Henry, as recorded by Baird in 1858. (Birds Pacific R. R. Survey, p. 104). Dr. Henry also obtained it at Fort Thorn (tom. cit. p. 921).

Hairy Woodpecker

Dryobates villosus, the hairy woodpecker, exists from the Atlantic to the Pacific in a variety of sub-specific forms. The form known as *harrisii* has been reported from Socorro County, N. M.; but it is now held that this bird belongs exclusively to the Pacific Coast, and consequently cannot have been found in New Mexico. Bendire reports the form *hyloscopus* as that found in New Mexico, but Mr. A. W. Anthony gives the name *montanus* to the birds ranging from New Mexico to Montana.

The bird, whatever it may be called, nests in dead trees, and is said to be especially abundant in regions where the timber has been killed by fires. Bendire says of it: "It is one of our most active woodpeckers, always busy searching for food, which consists principally of injurious larvæ and eggs of insects, varied occasionaly with a diet of small berries and seeds, and in winter sometimes of piñon nuts, pine seeds, and acorns. At this season I have often seen this species around slaughter houses, picking up stray bits of meat or fat, and have also seen it pecking at haunches of venison hung up in the open air."

Beal says: "The hairy woodpecker probably ranks next to the downy in point of usefulness. It eats fewer ants, but a relatively larger percentage of beetles and caterpillars." Mr. F. M. Webster has noticed that they will peck through the cocoons of the cecropia moth, and devour the pupæ within.

Batchelder's Woodpecker

This bird was separated from Gairdner's Woodpecker as a distinct sub-species *(Dryobates pubescens oræcus*)* in 1889, part of the series of specimens studied coming from Las Vegas Hot Springs, New Mexico. Its habits, food, etc., are said to be the same as those of the downy woodpecker. Capt. Bendire writes thus of the last-mentioned bird: "Unfortunately, it is also considered a sapsucker, and many of these exceedingly useful little woodpeckers are killed yearly through lamentable ignorance, under the supposition that they injure the fruit trees by boring in the bark, while in fact they render the horticulturist inestimable service by ridding his orchard of innumerable insects, their eggs and larvæ, and few of our native birds deserve our good-will more than the little downy woodpecker."

Mr. F. E. L. Beal says that of seven common woodpeckers whose food he studied, the downy woodpecker is the most beneficial. "Three-fourths of its food consists of insects, and few of these are useful kinds. Of grain, it eats practically none. The greatest sin we can lay at its door is the dissemination of poison ivy." In some cases the bird resorts to the ground and eats the eggs of grasshoppers.

Baird's Woodpecker

This belongs to the same genus as the last two, its scientific name being *Dryobates scalaris bairdi.* It is especially a bird of the mesquite region, and in Arizona it nests in the mesquite trees, which are of a different species *(Prosopis velutina,* Wooton) from the mesquite bush of New Mexico, although the two are closely allied. Captain Bendire says that this woodpecker is very fond of the ripe fruit of the giant cactus.

Arizona Woodpecker

The Arizona woodpecker, *Dryobates arizonæ*, has been found by Dr. Mearns in the extreme southwestern corner of

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*The scientific name has since been changed to *Dryobates pubescens homorus.*

New Mexico, but it is essentially a bird of southern Arizona and western Mexico. Mr. H. W. Henshaw reports that the birds observed by him in Arizona, "when in pursuit of food, almost always alighted near the base of the trees, gradually ascending and making their way along the smaller limbs and even out among the foliage, appearing to prefer to secure their food by a careful search rather than by the hard labor of cutting into the wood."

Alpine Three-toed Woodpecker

This is a northern bird, which, however, has been found in the region about Taos, New Mexico. I have no special information regarding its food, but there is no reason for considering it harmful.

Red-Naped Sapsucker

This woodpecker, the *Sphyrapicus varius nuchalis* of Baird, was originally described from New Mexico specimens. "In the fruit-growing sections within its range in southwest Utah, for instance, it is said to do considerable damage to the orchards in the early spring and again in the fall, tapping the peach and apple trees for sap in the same manner as *Sphyrapicus varius* does in the east. Its principal food consists of small beetles, spiders, grasshoppers, ants and such larvæ as are to be found under the loose bark of trees, as well as of wild berries of different kinds." [Captain Bendire] Mr. F. E. L. Beal says of the eastern sapsucker: "In localities where the bird is abundant considerable harm may be done to apple trees, which appear to be pleasing to its taste."

In New Mexico complaints have been received of the depredations of this bird, and there can be little doubt that it is a cause of more or less serious injury.

Williamson's Sapsucker

This, the *Sphyrapicus thyroideus* of ornithologists, is frequently observed in New Mexico. The stomach of one shot by Mr. E. Atkins at Conocita, above Cleveland, N. M., was full of ants (*Formica* sp.). Others shot on the upper Sapello river had eaten ants and beetles. This bird lives mainly in the coniferous forests, and there is no reason to consider it injurious. Bendire says: "It's food seems to consist almost exclusively of insects and their larvæ, various species of lepidoptera, and an occasional grasshopper." Coues tells us, "It is strictly a *Sphyropicus*, with little extensible, brushy and obtuse tongue, and feeds on juices of trees, as well as insects and berries."

Red-headed Woodpecker

This bird *(Melanerpes erythrocephalus)* has been observed by Mr. Chas. M. Barber at Hall's Peak, N. M., but it appears to be a rarity in New Mexico. Mr. Beal reports that it eats many beetles, apparently having a taste for those of large size. He also says: "The redhead has been accused of doing considerable damage to fruit and grain, and both charges are fairly well sustained. In northern New York Dr. Merriam has seen it peck into apples on the tree, and has several times seen it feed on choke-cherries."

Californian Woodpecker

Capt. Bendire says of this bird: "It is one of the most restless woodpeckers I know of, and never appears to be at a loss for amusement or work of some kind, and no other bird belonging to this family could possibly be more industrious. During the spring and summer its food consists, to a great extent, of insects, including grasshoppers, ants, beetles and different species of flies, varied occasionally with fruit, such as cherries, which are carried off whole, apples, figs, and also berries and green corn; but acorns always form its principal food supply during the greater portion of the year, and large numbers are stored away by it in the thick bark of pines, as well as in dry and partly rotten limbs of oak and other trees, also in telegraph poles and fence posts." Capt. Bendire adds, however, that the habit of storing acorns seems to be confined to the birds found in California and south-western Oregon, and that the somewhat smaller birds of Arizona and New Mexico never seem to act in this manner.

Lewis's Woodpecker

"In summer its food consists mainly of insects of different kinds, such as grasshoppers, large black crickets, ants, beetles, flies, larvæ of different kinds, as well as of berries, like wild strawberries and raspberries, service berries and salmon berries, acorns, pine seeds and juniper berries, while in cultivated districts cherries and other small fruits enter into its daily bill of fare. Here, when common, it may occasionally do some little damage in the orchards, but this is fully compensated by the noxious insects it destroys at the same time. In localities where grasshoppers are abundant they live on these pests almost exclusively while they last."—Capt. Bendire.

Gila Woodpecker

This bird occurs in southwestern New Mexico, but is properly a species of southern Arizona and adjacent Mexico. The specimens originally described by Baird in 1854 were from "Bill Williams' River, N. M.," but Bendire informs us that this is in Arizona. Its food is said to consist of various insects, and largely of cactus fruits and mistletoe berries. It is probably this species and the gilded flicker which, nesting in the giant cactus and feeding on the fruit of that plant, have come to transfer their attentions to the oranges in Salt River Valley, piercing them with their beaks and eating their contents.

Red=Shafted Flicker

This well known woodpecker is common in New Mexico, and is a great devourer of ants. One shot by Mr. E. Atkins at Conocita, above Cleveland, N. M., had the stomach full of ants, of two or more species. One shot on the Rio de las Casas had also eaten ants, not only the adults, but innumerable pupæ.

MISCELLANEOUS BIRDS

Sparrow Hawk

The American sparrow hawk *(Falco sparverius)* is common in New Mexico; Capt. Pope observed it at Doña Ana as long ago as Oct. 22, 1855. Dr. Fisher has well described the feeding habits of this bird in the following language:

"The sparrow hawk is almost exclusively insectivorous except when insect food is difficult to obtain. In localities where grashoppers and crickets are abundant these hawks congregate, often in moderate sized flocks, and gorge themselves continuously. Rarely do they touch any other form of food until, either by the advancing season or other natural causes, the grasshopper crop is so lessened that their hunger cannot be appeased without undue exertion. Then other kinds of insects, and other forms of life contribute to their fare; and beetles, spiders, mice, shrews, small snakes, lizards, or even birds may be required to bring up the balance."

The stomach of one shot by Mr. E. Atkins on the Rio de las Casas, N. M., contained the remains of a large beetle which was full of eggs. Another from the same locality contained grasshoppers and a large lepidopterous larva.

It is evident that the sparrow hawk is one of the most useful of birds.

Cooper's Hawk

While most of the hawks are decidedly beneficial, this species *(Accipiter cooperi)* has to be condemned on account of its habit of preying on small birds and poultry.

Mr. F. J. Birtwell informs me that in May, 1900, he was on the Pecos Reservation, and "a pair of these birds nested near my cabin. The amount of small birds they captured was very large. I hardly saw a day but what one or another of the pair was seen with a small bird, sometimes a robin."

Dr. Fisher says, "Cooper's hawk is very destructive to domesticated pigeons, and, when it finds a cote which is easy of approach, is very troublesome."

Road Runner

"Its food consists almost entirely of animal matter, such as grasshoppers,, beetles, lizards, small snakes, land snails, the smaller rodents, and not unfrequently of young birds. On the whole these birds do far more good than harm. When the fig-like fruit of the giant cactus is ripe they also feed on this; in fact, many animals and birds seem to be very partial to it. It is astonishing how large an animal can be swallowed by one of these birds. I have found a species of garter snake fully twenty inches long in the crop of one shot in Arizona."—Captain C. Bendire.

Captain Bendire also quotes Mr. Anthony as stating that the road runner has in several cases been known to make a meal of a nest of young house-finches, and other small birds.

As a destroyer of snakes, this bird must be considered somewhat harmful, since very few of our snakes are poisonous, and many of them do great service in destroying gophers and similar destructive animals.

California Cuckoo, or Western Yellow-Billed Cuckoo

Captain Bendire once observed a nest of this bird "placed in a clump of willows, within a few feet of where I was camped, and my attention was first attracted to it by the uneasy manner in which the parents moved through the willows, constantly flitting back and forth, and always with a large, black cricket, *Anabrus*, in their bills, on which they seemed to feed their young entirely." Captain Bendire further noticed that this bird seemed invariably to build its own nest, and in no case to lay its eggs in the nests of other birds; as several of its relatives do.

The eastern yellow-billed cuckoo is a great destroyer of caterpillars, including the cankerworm and tent caterpillar. No doubt the western bird, which is only subspecifically distinct from that of the east, has similar habits.

The cuckoo, therefore, is a most beneficial bird.

Belted Kingfisher

"While different kinds of small fish undoubtedly constitute a large part of the kingfisher's food where readily procurable, various species of crustacea, as well as insects such as coleoptera, grasshoppers, and the large black crickets found in many of our Western states, are also eaten to a greater or less extent, according to circumstances; frogs and lizzards are also acceptable prey. In southern Arizona, for instance, where running streams are few, I have found kingfishers breeding in localities where fish must have formed but a small percentage of their daily fare; there they lived principally on lizards, beetles, and large grasshoppers. I have more than once seen one of these birds perched on some twig overhanging a dry, sandy river bed, where no water was to be found within several miles, on a watch for the kind of food procurable in such localities."—Capt. Bendire.

These kingfishers are found along the Gallinas River, near Las Vegas, where they doubtless live on the small fish inhabiting the river. The fish living in this part of the Gallinas (kindly identified for me by Dr. B. W. Evermann) are *Leuciscus nigrescens* and *Rhinichthys cataractæ dulcis.* These are small fish, of no economic importance. Dr. Bendire says, "By far the larger number of fish caught by the kingfisher consist of species not considered worth much as food fishes, and they rarely average over three inches in length." Mr. Wm. Jones tells me that at the Kronig Lakes, N. M., he saw Kingfishers take comparatively large fish, six inches or over in length.

The Shrike

The white-rumped Shrike *(Lanius ludoricianus excubitoroides)* is a common bird in the Mesilla Valley, and everyone knows how it hangs lizards, grasshoppers, and even mice and snakes, upon the mesquite thorns. Mr. Birtwell reports the shrike as preying on garter-snakes and grasshoppers.

The Band-tailed Pigeon

Mr. Birtwell reports that this bird *(Columba fasciata)* feeds almost exclusively on acorns during the winter.

The Poor-will

Dr. R. W. Shufeldt, as Mr. Birtwell informs me, has recorded (Auk, Oct. 1885) that the Poor-will *(Phalænoptilus nuttallii)* was seen at Fort Wingate capturing moths, and some of the birds when shot were found to have their throats packed with them. They caught the moths by leaping in the air two or three feet from a gravel walk.

The Evening Grosbeak

A large flock of these beautiful birds *(Cocothraustes vespertinus montanus)* visited Las Vegas in the fall of 1900, and everyone had an opportunity to see them eating the seeds of the box-elder.

APPENDIX.

COUNCIL BILL NO. 3

An Act to prevent the killing of birds in the Territory of New Mexico

Be it enacted by the Legislative Assembly of the Territory of New Mexico:

Section 1. That it shall be unlawful for any person or persons in this territory to wantonly shoot, snare or entrap, for the purpose of killing, or in any other manner to destroy, any song bird, or birds whose principal food consists of insects; comprising all the species and varieties of birds represented by the several families [species] of blue-birds, including the western and mountain blue-birds; also road-runner, woodpeckers, night-hawks, humming birds, phoebe-birds, fly-catchers, pewees, piñon jays and other varieties of the jay family; blackbirds, meadow-larks, orioles, Mexican ojolotles, Arizona gold finches, swallows, yellow-throats, thrashers, wrens, mocking-birds, Rocky mountain creepers, nut hatches, robins, chickadees, gnat-catchers, thrushes, Oregon or "Denny pheasant," and all other species and varieties of birds, regarded as harmless in their habits, and whose flesh is unfit for food; except such as are destructive to orchards, gardens and fields, or crops of fruit, berries or grain. *Provided*, that nothing in this act shall be construed to prohibit the killing of any such birds for scientific purposes.

Section 2. Any person or persons violating the provisions of this act shall be punished by any court before whom complaint may be made, by a fine not to exceed fifty dollars and not less than ten dollars, or by imprisonment in the county jail, not to exceed thirty days and not less than ten days. Each bird killed, injured or in any way disposed of shall constitute a separate offense under the provisions of this act.

Section 3. This act shall take effect from and after its passage.

Approved March 14, A. D. 1901.

NOTE—I was not able to obtain a copy of the above bill before its passage. It represents a move in the right direction, but it would be hard to show that the flesh of many of the birds mentioned is "unfit for food," and it would take an expert to determine whether the several kinds were at all "distructive to orchards, gardens and fields, etc." The mocking bird, for instance, is mentioned; but Mr. F. E. Lester writes me from Mesilla Park that this bird every summer eats the apples on his trees. Last summer one tree, the best on his place, bore probably two hundred good apples, but all were eaten by the birds before becoming ripe. In reality we do not yet know enough of the habits of New Mexico birds to say in every case which is harmful and which useful, though in most instances we can doubtless form a reasonable opinion.

T. D. A. C.

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BULLETIN NO. 38 MAY, 1901

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

SOIL AND SOIL MOISTURE INVESTIGATIONS

FOR THE SEASON OF 1900

BY

J. D. TINSLEY and J. J. VERNON.

The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others so far as the editions printed will allow.

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1901

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ARTICLE I

Physical Character of the Soils of Twelve Plats used in Soil Moisture Experiments with Corn

BY

J. D. TINSLEY

INTRODUCTION—SCOPE OF SOIL PHYSICS

Since the days of the great German chemist, Liebig, chemists have busied themselves with the study of the soil, especially its *chemical* composition, but it is only within a comparatively few years that any considerable attention has been devoted to the *physical* characters of soils.

Soil Physics, or the study of the physical properties of soils, is then a comparatively new line of investigation, and like all other branches of science its boundaries are not sharply defined, many inquiries leading us into the fields of chemistry and of plant physiology. Some of the more important lines of investigation in soil physics are, study of soil textures; relations of the sizes of the soil particles and water holding capacity in a given volume; capillarity, or the property by virtue of which water is brought up from below; specific gravity; color; relations of soils to heat, etc. The department of soil physics in this Station is also including in its work, a study of seepage or sub-irrigation, "alkali," and the reclamation and improvement of sub-irrigated alkali lands.

SAMPLING

Before taking up the characters of the soils the writer wishes to say a few words on sampling; for the value of other results depends very largely on the accuracy of the sample from which they are obtained. It is scarcely practicable to go to a greater depth than 18 inches with a sampling tube in the soils on the Experiment Station farm, and it is but seldom that this depth can be attained without considerable difficulty, 6–12 inches being the practical limit.

We use a *tube sampler* made of No. 16 brass tube with a ring of clock spring soldered into one end, and this end then filed down to a cutting edge. Experience has shown that more uniform results can be obtained, especially in moisture samples, by the use of large tubes. The first tubes used were $\frac{3}{4}$ inch in diameter.

For taking samples at greater depths than can be done with the tubes, augers are used, of which we have tried three forms.

The *Soil Borer*, fig. 9322 of Eimer and Amend's catalogue, 80 millimeters (equals about three inches) in diameter, cuts very well and draws out the soil nicely when in proper moisture condition. This borer will also work in very dry soils but it works slowly because it can only draw out a cone whose base is the diameter of the auger and whose height is determined by the angle of flow of the material.

Wood Augers of Various Sizes

These have the stem lengthened to 3 ft., upset on the end and threaded to take $\frac{3}{8}$ inch pipe couplings; the stem is extended by using 3 ft. lengths of $\frac{3}{8}$ pipe. Either black or galvanized pipe may be used for this purpose; and while the galvanized pipe does not rust and is rather nicer to handle, yet the writer has been much inconvenienced on several occasions by the breaking of the galvanized pipe at the couplings, this trouble not having occurred with black pipe.

These wood augers are very satisfactory for sampling when the soil is moist enough to stick to the auger. There are, however, many occasions when soils in the Mesilla Valley are too dry to stick to the ordinary auger, and sampling becomes very difficult; this is especially true of dry sands. When samples are wanted for certain purposes it is of course permissible to pour water into the hole and thus make the soil hold together, but of course this cannot be done in moisture work.

Auger with Casing

(Plate I.) The writer has devised the following form of auger, which after 12 months of use has proved very satisfactory. A two-inch wood auger was ground down so that it would fit loosely within a piece of $1\frac{7}{8}$ inch No. 16 brass tube. The diminished diameter extended to within three-fourths of an inch of the cutting edge, thus forming a shoulder (a) of about $\frac{1}{8}$ of an inch on each side, on which the tube rests. A hard wood plug with a hole in the center through which the auger stem passes, is fastened into the top of the tube by four small wood screws. This plug is sawed in half so that it can be removed if necessary. Above the plug is placed a collar carrying a set screw by means of which it can be fixed to the stem and thus prevent the tube sliding up. This collar was made by reaming out a common bolt nut to the required size, (the stem of this auger being $\frac{1}{2}$ inch in diameter) boring and threading a $\frac{5}{16}$ inch hole in its side, and putting in a $\frac{5}{16}$ inch set screw. The casing is 11 inches long, the thread of the auger being 8 inches. Of course the collar has to be put on before the upper end of the tube is upset, and cannot be removed. A detachable collar would perhaps be more convenient, although the collar when fastened at the upper end of the stem is not in the way when working the auger without the casing. The casing does not work very well when the soil is wet enough to stick to it, and it may then be removed with advantage. When the soil is in ordinary moisture condition the set screw need not be tightened and the casing will move up and down and give no trouble. When, however, the soil is very dry it is best to tighten the collar, leaving the casing about two inches of play, up and down, and the soil will then be drawn up into the casing and may easily be removed from the hole. This plan may also be used when it is desired to prevent the sample from being moistened or mixed with the soil above. With this auger one should be able to bore in moderately dry soils, at the rate of a foot in five minutes, to a depth of at least 10 feet, provided the soil does not contain too much coarse gravel.

TEXTURE

The principal types of soil texture are clay, clay loam, loam, sandy loam, and sand.

All are familiar with the fact that some soils are very sticky when wet and bake very hard when dry; such a soil is called a clay or clayey, and in New Mexico it would be called "adobe." Other soil is found to consist of distinct grains, visible to the naked eye, and these grains show very little or no coherence when wet; such a soil we call a sand. Between the heavy clay on the one hand and the coarse sand on the other we find every gradation.

The essential difference from a physical point of view, between a clay and a sand, lies in the difference in size of the particles. If we take a quantity of soil and stir it up thoroughly with water and then take a small quantity of this mud and examine it under a microscope, of fairly high magnifying power, we will find that this drop of mud is made up of grains of various shapes and sizes. In size they may range from 2 millimeters down to .0001 of a millimeter or less, anything greater than 2 millimeters being called gravel.

Mechanical Analyses

A mechanical analysis consists in separating out these particles between certain limits of size, and determining the amount of the particles present which come within these limits. We shall use the limits and terms adopted by the Division of Soils of the United States Department of Agriculture, which are as follows: Over 2 millimeters (1 mm. = about 1-25 inch) = gravel etc., 2 - 1 mm. = fine gravel, 1 - .5 mm. = coarse sand, .5 - .25 mm. = medium sand, .25 - .1 mm. = fine sand, .1 - .05 mm. = very fine sand, .05 - .01 mm. = silt, .01 - .005 mm. = fine silt, .005 - 0001 mm. = clay.

Method and Apparatus

A brief outline of the method and apparatus used in making mechanical analyses may be of interest so some of our readers: for a detailed and extended account of this subject the reader is referred to Bulletin No. 4, and Report No. 64 of the Division of Soils, United States Department of Agriculture.

When the sample is brought into the laboratory from the field it is spread out and allowed to dry thoroughly in the air. It is then pulverized by rolling and passed through a sieve having round holes 2 millimeters in diameter. If there is any (appreciable amount of) gravel that will not pass through this sieve it is washed, dried, and weighed and its percentage of the whole sample determined. There is seldom more than a trace of such gravel in the soil of the Station Farm. The heavy adobe soil is so hard when dry that it is almost impossible to crush it by rolling; hence, in this laboratory, it is passed through a small Blake ore crusher, which readily reduces it to the necessary fineness. The jaws of the crusher are set so far apart that they will not crush the gravel over 2 mm. in diameter. The samples are then thoroughly mixed and placed in airtight glass jars. Ten grams of the samples are then placed in bottles, 150 cubic centimeters of water, and a trace of ammonia added, the stoppers put in and tied down, and the bottles placed in the shaker. 12 of these bottles are usually placed in the shaker at once.

The shaker used in this laboratory (Plate 2) consists of a frame in which is suspended a double shelf; the shelf swings back and forth and thus keeps the soil constantly agitated. The laboratory not being supplied with power, it was necessary to get some form of motor that would keep the shaker in constant motion, and a six-inch Pelton water motor was finally decided upon. The average head of water on the motor is about 9 ft. (about 4 lbs. per sq. inch pressure), and this is just sufficient to run it at about 100 revolutions per minute. The motor is set in the sink and the supply pipe attached to the faucet, and when the shaking is completed it is simply disconnected and set out of the way. The samples are shaken for 8 to 10 hours, at the end of which time the particles are usually washed entirely free from each other. Sandy soils take rather less time, and in some of the soils there are flakes of adobe sediment which show no appreciable disintegration after 12 hours of shaking. The samples are usually shaken eight hours and then the flakes of adobe are disintegrated by rubbing in the centrifuge tubes with a rubber tipped glass rod. These flakes are probably a portion of the fine sediment deposited from the muddy irrigating water. The samples are now transferred to glass tubes holding about 100 cubic centimeters, and these placed in a centrifuge.

The centrifuge used is the "Universal," fig. 8665A of Eimer and Amend's catalogue, and is run by hand, four tubes usually being run at one time. The tubes are whirled until every thing coarser than clay has settled out. This is determined by taking a drop of the liquid and examining it under a microscope, and measuring the size of the particles. This liquid is then poured off and more distilled water added under pressure from a jet, and the mud thoroughly stirred up. (The pressure is obtained by placing the water reservoir in the attic of the building.) The mud is again whirled, examined, and decanted, and the process continued until all the clay has been removed. The fine silt is then separated in the same manner, then the silt, leaving finally all the grades of sand together. The sand is then dried, ignited, and separated into the grades by means of sieves. The water carrying the clay is evaporated off, the clay dried, ignited, then subjected to a stream of carbon dioxide for an hour, gently reignited and weighed. The fine silt and silt are treated like the clay.

The residue called clay, when obtained as above, contains also most of the soluble material of the soil; when the amount of this is appreciable, it is determined by the electrical method in the clay water before evaporation, and the amount of the salts found deducted from the clay. In the analyses given in Table 1 the "salts" were determined, by the electrical method, in the clay water after it had been concentrated to about 100 cubic centimeters. These results are probably low, as a part of the gypsum is probably precipitated in concentrating the solution. If, the resistance is determined in the total volume of clay water the ammonia which was added to prevent flocculation would make the results appear too high.

TABLE I

Plat	Depth	Texture	Water capacity	Mechanical Analyses											
				Fine gravel Diam. 2-1 mm	Coarse sand Diam. 1-.5 mm	Medium sand Diam. .5-.25 mm	Fine sand Diam. .25-.1 mm	Very fine sand Diam. .1-.05 mm	Silt Diam. .05-.01 mm	Fine silt Diam. .01-.005 mm	Clay Diam .005-.0001 mm	Salts	Loss at 110° C.	Loss on ignition	Total
No			*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*	*Per ct*
1	0-1 ft	Loam	34.6	0.00	.19	.76	15.55	49.45	9.33	8.18	11.41	.20	1.25	4.16	100.48
1	1-2 ft	Loam	37.5	0.00	Trace	1.35	8.03	61.65	11.69	4.22	7.33	.16	1.67	3.12	99.22
1	2-3 ft	Sandy loam	32.5	.27	.99	17.27	41.21	18.33	8.57	2.73	7.26	.30	1.23	1.86	100.02
1	3-4 ft	Sand	29.6	.15	.59	14.57	62.93	13.94	2.08	1.26	1.80	.10	.41	.81	98.64
1	4-5 ft	Sand	25.8	Trace	1.59	18.00	64.55	11.46	.85	.64	1.25	.10	.34	.63	99.41
1	5-6 ft	Sand	24.2	.68	2.94	40.04	47.93	5.68	.75	Trace	1.00	.10	.29	.53	99.94
1	6-7 ft	Sand	25.0	.73	4.79	37.60	46.55	5.11	Trace	1.28	1.67	.10	.28	1.41	99.52
1	7-8 ft	Sand	23.8	.73	5.08	47.20	38.02	4.26	Trace	1.54	2.07	.10	.28	1.40	100.68
1	8-9 ft	Sand	22.3	5.75	14.30	46.03	26.19	2.64	Trace	1.95	1.72	.10	.32	.59	99.58
1	9-10 ft	Sand	23.3	1.30	5.44	42.92	42.54	3.40	Trace	1.38	1.39	.10	.41	.73	99.61
1	3-6 in	Clay loam	38.7	0.00	Trace	.49	11.06	42.82	11.71	5.28	20.48	.30	1.77	4.42	98.33
1	15-18 in	Loam	36.5	0.00	0.00	.10	5.12	67.93	12.61	5.35	4.22	.25	1.22	2.46	99.26
2	3-6 in	Clay loam	37.2	0.00	Trace	.38	6.63	42.10	8.25	3.77	30.70	.70	2.25	4.82	99.60

2	15-18 in	Clay loam	38.00	0.00	Trace	.40	4.61	47.60	24.76	3.43	11.76	.50	1.55	4.40	99.01
3	3-6 in	Clay loam	38.10	0.00	Trace	.96	13.61	37.81	9.41	3.92	28.00	.30	2.30	5.28	101.32
3	15-18 in	Sandy loam	31.2	.23	.51	1.59	16.79	59.52	6.48	5.06	4.80	.15	1.42	3.86	100.41
4	3-6 in	Clay loam	41.6	0.00	Trace	.43	9.61	35.64	11.19	11.00	22.38	.22	2.70	5.96	99.13
4	15-18 in	Clay	44.9	0.00	Trace	1.27	4.11	19.21	9.85	9.25	45.19	.40	3.10	7.12	99.80
5	3-6 in	Loam	36.8	0.00	0.00	.62	27.52	37.09	6.20	5.84	16.70	.27	1.62	4.00	99.86
5	15-18 in	Clay loam	39.8	0.00	.10	.19	3.87	22.59	10.97	15.89	36.66	.16	4.14	5.80	100.67
6	3-6 in	Clay loam	41.4	0.00	.10	.73	6.39	22.01	13.30	15.00	32.11	.17	3.40	6.60	99.84
6	15-18 in	Clay	42.2	0.00	Trace	.37	1.76	8.54	18.39	20.09	38.61	.21	4.71	7.44	100.18
7	3-6 in	Clay loam	40.3	0.00	Trace	1.08	7.25	31.16	16.31	9.36	25.40	.18	3.19	5.84	99.77
7	15-18 in	Clay	45.3	0.00	0.00	.20	1.35	9.84	20.39	14.00	40.07	.25	5.32	7.88	99.30
8	3-6 in	Clay loam	40.3	0.00	0.00	.25	15.25	35.26	11.13	10.50	19.28	.18	2.79	6.25	100.89
8	15-18 in	Clay	46.5	0.00	0.00	Trace	1.55	11.17	25.72	15.81	31.19	.28	4.21	7.90	100.86
9	3-6 in	Clay loam	42.5	0.00	0.00	.20	7.54	30.04	20.00	11.15	21.95	.21	3.40	6.64	101.16
9	15-18 in	Clay	44.0	0.00	0.00	Trace	1.42	11.52	17.08	12.08	44.05	.28	5.31	8.14	99.88
10	3-6 in	Clay loam	42.2	0.00	Trace	.20	3.59	36.19	21.58	10.98	17.62	.20	2.98	6.09	99.43
10	15-18 in	Clay loam	38.3	0.00	Trace	.15	1.69	32.79	31.60	9.43	15.28	.15	1.18	6.17	98.44
11	3-6 in	Clay loam	46.2	0.00	0.00	.24	3.91	33.72	22.14	10.38	19.60	.21	3.15	6.56	99.91
11	15-18 in	Sandy loam	32.5	0.00	Trace	.22	2.97	56.35	19.58	6.32	7.08	.30	1.84	4.00	98.66
12	3-6 in	Clay loam	45.2	0.00	.11	.43	3.14	30.23	20.85	11.93	22.95	.15	2.75	6.10	98.64
12	15-18 in	Loam	37.3	0.00	0.00	.20	2.46	51.68	24.86	6.00	8.22	.18	1.90	4.44	99.91

Explanation of Table 1 and Plates 3-7

In the column headed "Texture" is given the textures as rated by mixing the soil with water and noting the tenacity of the mud. The per cent of salts given in the table does not represent the salt content of the soil, but that soluble matter which is dissolved in making the analysis. The quantity of these dissolved salts is rather low in these samples, it may reach 5 per cent or more in some "alkali" soils.* The "traces" of materials more than .25 mm. in diameter are principally scales of mica. There is a considerable amount of mica in each of these samples.

Plates 3–7 show the materials separated in the analyses, and illustrate the relative weights expressed in percentages. In these the percentages are expressed to the nearest tenth, and the percentage of clay is not corrected for the percentage of salts.

Plates 3, 4, 5, the upper line of plate 6, and the corresponding analyses in Table 1, show the variation in texture encountered in passing from the surface down to the water table on Plat 1. The 7th, 8th, 9th and 10th ft. are a white sand and are practically uniform under the whole farm.

The lower line of Plate 6 illustrates the clay ("adobe") found on Plat 4 at 15 – 18 inches.

Plate 7, upper line, illustrates the clayey loam found in plat 5 at 15 – 18 inches, and the lower line shows the loam found at 3 – 6 inch on plat 5. The samples were taken 150 feet apart from north to south and from east to west, the 3 in. – 6 in. and 15 in. – 18 in. samples being taken from the same holes.

FORMATION

In bulletin No. 31 of this station, these soils were stated to have been deposited by the river. A more careful study of this point show that wash from the adjacent foot hills has also played an important part in their formation. In fact there are four factors which have entered into their formation:

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*See analyses in Report No. 64, Division of Soils, United States Department of Agriculture.

First, river deposit. This piece of land is near an old river bed: the Rio Grande has changed its bed in this part of the valley several times; the river is now about three miles west of the Station farm; and the old beds are still sharply defined, the banks still being almost vertical.

Second. Wash from the foothills. This material is brought down by the arroyos when there are rains on the foothills and plains to the east.

Third. Sediment from the irrigating water. This sediment being a heavy clay in texture, and being deposited at the rate of about ¼ inch per year, * has no doubt an important action in modifying the texture of the cultivated layer of the soils.

Fourth. Drifting of soil by the winds. The soils being often dry and sandy and there being a great deal of wind, blowing often with a velocity of twenty or more miles per hour, there is considerable material moved. This wind is principally from the west, and it may effect either a removal from or an addition to these soils. Its building effect is well shown in many places in the valley, especially where vegetation is dense enough to cause the material to be deposited, and the wearing effect is well shown on the roads.

These different methods of deposition have resulted in making these soils very uneven in texture. Numerous borings have shown that the soil has not been laid down in uniform layers, but rather in pockets, with no definite sequence in the order of deposition. Table 1 does not bring out the difference in texture of the different layers which compose the whole soil, so well as a map would, yet it will give some idea of the differences. It will be noticed that while to the eye, and when rated by their coherence, the different 3–6 inch samples appear quite uniform, being rated principally as clay loams, yet when we examine the amounts of the different grades of material they are found to vary considerably. The fine sand varies from 3.1 per cent on plat 12, to 15.2 per cent on plat 8; the very fine sand from 22 per cent on plat 6 to 42.8 per cent on plat 1; the silt from 8.2 per cent on plat 2 to 22.1 on plat 11; the fine silt from 3.8 per cent on plat 2 to 15 per cent on plat 6; the clay from 17.6 per cent on plat 10 to 32.1 per cent on plat 6. Comparing the textures of the 3–6 inch samples with those of the 15–18 inch samples, we find the variations in texture well marked, and the lower sample is usually the heavier, though in certain plats it is lighter. These differences are brought out more clearly by the following comparisons of vertical sections on these plats.

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*See New Mexico Station Bulletin No. 12, page 52.

TABLE 2

Depth	No of plat	1	2	3	4	5	6	7	8	9	10	11	12
0-6	Texture	SCC	SSC	SC	C	SCC	SC	SC	SC	SCC	SCC	SCC	SCC
6-12	"	C	SSC	SC	C	C	C	SCC	SC	HC	SCC	SCC	SCC
12-18	"	SCC	SC	S	SSC	SCC	HC	C	C	HC	SCC	SCC	SC
18-24	"	SC	SC	C	SSC	C	HC	C	C	SC	SSC	SCC	SC

TABLE 3

Depth	No. of plat	1	5	8	10
0-1 ft	Texture	SC	SC	SCC	SC
1-2 "	"	SC	SCC	C	SCC
2-3 "	"	SSC	C	SSC	SC
3-4 "	"	S	SCC	SCC	C
4-5 "	"	S	SC	SCC	SC
5-6 "	"	S	S	S	S
6-7 "	"	S	S	S	S
7-8 "	"	S	S	S	S
8-9 "	"	S	S	S	S
9-10 "	"	S	S	S	S

S — Sand.
SSC — Sandy loam.
SC — Loam.
SCC — Clayey loam.
C — Clay.
HC — Heavy Clay. *

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* The samples of heavy clay are usually reddish in color and are called by the Mexican name, "Barro."

The sand found below 3 to 5 feet is white in color, rather sharp, and is quite uniformly distributed over the whole farm. The water table is about 10 to 12 feet below the surface of the ground.

These differences in texture have not only a marked effect on the water capacity, but also upon the rate at which water passes through the soil, sand allowing the water to pass through rapidly, while the clay allows it to pass through very slowly.

In this connection it may be stated that the ideal soil, at least for cultivated crops, in the Mesilla Valley consists of 2–4 feet loam underlaid by a layer of heavy clay. The clay forms a nearly impervious layer so that the water is held in the loam for the use of the crop.

POROSITY AND WATER CAPACITY

The amount of water necessary to saturate a soil depends on several factors, the most important of which is the "porosity," or amount of space between the soil particles.

"The porosity of a soil depends upon the size of the soil particles (or texture) and the way in which these particles are grouped together, and upon the space between the particles or groups of particles. If a soil be cemented together into a homogeneous mass, its porosity sinks to a minimum; if it be composed, however, of numerous fine particles, each preserving its own physical condition, the porosity of the soil will rise to a maximum. The porosity of a soil may be judged very closely by the percentage of fine particles it yields on mechanical anylisis. A finely divided soil has a high capacity for absorbing moisture and holding it." (Wiley, Agricultural Analyses, Vol. I.)

The porosity of the first six inches of the soil, near the electrodes, in each plat was determined by the Whitney Method as described by Wiley (Agricultural Analyses, Vol. I.) For the results see table 4.

TABLE NO. 4

Plat	Depth.	Texture.	Specific gravity.	Water capacity per ct. of dry wght	Per cent. by vol. of soil.	Per cent. by vol. of space.	Per cent. by vol. of water.	Difference per cent. by volume.
1	0-6 inches	clay loam	2.65	38.7	48.7	51.3	49.8	1.5
2	0-6 inches	clay loam	2.66	37.2	48.5	51.5	47.9	3.6
3	0-6 inches	clay loom	2.59	38.1	46.9	53.1	46.2	6.9
4	0-6 inches	clay loam	2.65	41.6	50.4	49.6		
5	0-6 inches	clay loam	2.72	36.8	47.5	52.5	47.5	5.0
6	0-6 inches	clay loam	2.7	44.4	43.5	56.5	52.1	4.4
7	0-6 inches	clay loam	2.65	40.3	45.4	54.6	48.4	6.2
8	0-6 inches	clay loam	2.65	40.3	47.8	52.2	50.9	1.3
9	0-6 inches	clay loam	2.64	42.5	43.9	56.1	49.2	6.9
10	0-6 inches	clay loam	2.63	42.2	47.9	52.1	53.1	—1.0
11	0-6 inches	clay loam	2.62	46.2	43.6	56.4	52.7	3.7
12	0-6 inches	clay loam	2.60	45.2	45.0	55.0	52.8	2.2

The per cent, by volume, of space is seen to vary between 51.3 and 56.5 per cent.

Methods For Determining Water Holding Capacity

A number of methods have been proposed for determining the water holding capacity of soils and among these the writer has tested three: First, the method described by J. L. Beeson (Journal of the American Chemical Society, Vol. XIX, No. 8, August 1897.) The writer had the improved form of apparatus figured in that paper made (this tube had a diameter of 35 mm.), and also used the simpler form, which was made by cutting off one end of a 200 cc. pipette and fitting a perforated disc carrying a central tube (the diameter of this tube was 45 mm.) Another was made having a side tube, the main tube having an internal diameter of 22 mm. and being 20 cm. long. This held 50 grams of soil instead of 100 grams. A third was made by cutting off the bottom of a bottle, having an internal diameter of 70 mm., and thus giving a depth of about 2 cm. with 100 grams of soil.

A fourth form of apparatus consisted of an 8 oz. Erlenmeyer flask with the bottom cut off, and a disc and centre tube fitted to the bottom of the paper at the neck.

The object in using these various forms of tubes was to study the effect of the length and diameter of the soil column on the per cent of water retained. Working on the same soil sample under practically uniform conditions the results were as follows:

a The results with each tube were fairly uniform among themselves, the maximum variation being 3 per cent.

b The small tube gave the lowest results; the 35 and 45 mm. tubes gave results practically identical but about 4 per cent higher than those obtained with the small tube. The conical tube gave results 5 to 10 per cent higher than the 35 mm. tube; and the 70 mm. tube gave about 5 per cent higher than the 35 mm. tube.

From these trials we would conclude that the diameter of the tube has a marked effect upon the percentage of water held in the colums of soil.

A further comparison was made between the Beeson volumetric, the Wolff-Wahnschaffe method as described by Wiley (Agric. Analyses, Vol 1), and a modification of the method of A. Meyer (See Wiley, Agric. Anal. Vol. 1).

The Wolff-Wahnschaffe method was used essentially as described, the only modification being that, instead of using nickel wire gauze for the bottom of the tubes, copper gauze, one hundred mesh, was used, and with this it was not found necessary to use a linen disc. This method gave concordant results, and was used in making the determinations given in tables 1 and 2.

In the Meyer method a 2-inch No- 16 brass tube was used instead of the glass tube and, the top sections were six inches long, the pieces being united with rubber tubing. This method did not give concordant results, and does not seem to the writer to be worth further study.

TABLE 5

	a	b	1	c	d	2	e
	Moisture per cent. dry wt.						
Expt. 1	33.1	30.0	33.3	28.3	29.2	30.3	28.5
Expt. 2	24.7	26.1	24.3	26.3	26.1	26.1	25.3
Expt. 3	29.2	30	31.6	31.4	29.4	24.	30.5

Table 5 gives the results of 3 trials. The samples in column "a" were taken from the top of the upper section of soil; those in "b" from the bottom; "1" represents the remainderof the soil in the upper section dried as one sample; "c" the top, and "d" the bottom of second section, "2" the remainder of the soil in this section; "e" the top of the long bottom section. The moisture was determined by drying and weighing.

All moisture determinations in this bulletin are expressed in terms of dry weight of soil unless otherwise stated.

The *first* objection to the use of the Meyer method is that, one 50 gram sample cannot be relied upon to give the amount of moisture present. When the contents of a section are used it gives a sample of about 350 grams.

Second. The amount of soil required to make a test is larger than is often available when samples are sent to the Laboratory from a distance.

Third. It is difficult, with brass tubes at least, to so regulate the drainage as to wet equal lengths of soil columns each time.

The Wolff-Wahnschaffe method requires only about 250 grams of soil per tube, and two out of three duplicates will usually agree within one per cent.

No direct comparisons have yet been made between the Wolf-Wahnschaffe method and the moisture contained in the soils in the field immediately after irrigation, but results obtained in the moisture work of the past season indicate that the agreement will be fairly close. This matter will be investigated during the coming year. In table 6 will be found a comparison of the results of these three methods, all the determinations being made upon portions of the same sample.

TABLE 6

	1	2	3	Average
Beeson's	46.2	44.	44.2	44.8
Modified Meyer	33.2	24.3	31.6	29.7
Wolff-Wahnschaffe	35.5	35.9	35.9	35.8

Results. After making the comparisons, the Wolf-Wahnschaffe method was decided upon as giving the most concordant results, and the water holding power of each of the samples from the 12 plats was determined by this method. The results are given in table 1.

In table 4 the percentage of space in the upper 6 inches of the soil of each plat, is compared with the volume of water absorbed by the same soils. This volume of water is obtained by the Wolff-Wahnschaffe method on the 3–6 inch samples, and is assumed to be equal to the space included in the dry soil. With the exception of the sample from plat 4 the agreement is quite close, especially when we consider that in determining the porosity the soil was taken in as nearly as possible its natural cultivated condition; while in determining the water capacity the samples had been air dried, pulverized to pass through a 2 millimeter sieve, and then packed into the zinc tubes by jolting. There is probably an error in the result on plat 4, and omitting this result we find that the maximum difference is 6.9 per cent while the average difference is 4.2 per cent. In only one instance is the amount of water greater than the space it should fill, and that is in the results on plat 10. The differences mean that there is more space in the upper 6 inches than would be filled by the water these soils could hold, as determined by the Wolff-Wahnschaffe method, and would therefore represent a maximum of about 7 per cent of space filled with air, when the soil is saturated with water. Another point which should be considered in this connection is that the 0–6 inch samples were taken when the soil was quite dry and lumpy from frequent cultivation, and therefore had apparently more space than it would have had when compacted by irrigation. Upon calculating the water capacity in terms of the depth of water in inches on a depth of one foot of soil, we find that the surface soil of these plats requires about 6 inches of water to saturate the surface foot. This is assuming that the porosity of the first foot is the same as that of the first 6 inches. The influence of percolation of course comes in, and if we applied 6 inches of water to one of these clay loams we would not, after a short time, expect to find the surface foot saturated, for some of the moisture would pass down into the second foot. Just what effect it would have on the moisture content of the second foot we can not say at present, this side of the subject will be investigated during the coming year. We notice that loams (plats 1 and 5) hold considerably less water than the clay loams and clays, and that the white sand has a very much lower water capacity.

It seems to the writer that the matter of water capacity should be taken into consideration when studying the moisture content of a soil, for it is scarcely to be assumed that a clay soil with 10 per cent of moisture is as favorable for plant growth as a sandy loam with ten per cent of moisture. This matter is of special importance when we come to compare the moisture conditions of soils of different textures, as in a study of the effects of cultivation on soil moisture. For a further discussion of this subject see Art. 2 of this bulletin.

ACKNOWLEDGMENTS

The writer wishes to acknwledge the assistance of Mr. Alfred M. Sanchez, student assistant in soil physics, in much of the laboratory work reported in this article, and to Prof. F. W. Brady, of the mechanical engineering department, for the photographs from which the cuts were made.

ARTICLE II

Soil Moisture Experiments for the Season of 1900

BY

J. D. TINSLEY and J. J. VERNON

INTRODUCTION

The experiments on soil moisture reported in bulletin No. 31 of this station were repeated during the season of 1900. As before, the work was carried on jointly by the departments of agriculture and soil physics. The department of agriculture took charge of the planting cultivation, irrigation, observations on growth and yield; while the work on soil character and the determinations of moisture was done by the department of soil physics.

We wish to acknowledge the assistance of Mr. Fabian Garcia, now horticulturist of the station, who made the field observations and superintended the irrigation and cultivation for the department of agriculture, and Mr. A. M. Sanchez, student assistant in soil physics, who made practically all of the moisture determinations, both by sampling and weighing and weighing and with the soil hydrometer.

PLAN OF EXPERIMENTS

The experiments were repeated on the piece of land used for the moisture experiments of 1899. This piece of land embraced about three acres and was divided into twelve, practically equal plats. It is located near the main ditch, but is irrigated from the ditch which forms its northern boundary. The field not being quite level, it was necessary to put in a lateral ditch between the first and second rows of plats, and another between the third and fourth rows, and, to further equalize the distribution of the water, borders were made which divided each plat into four sections. Figure 1 shows the arrangements of the plats, the dotted lines showing the borders.

After examing the root development of the corn in 1899 it was decided that 3–6 and 15–18 inches would probably be better depths for the moisture determinations than 6–9 and 21–24 inches, which were the depths used in 1899. The electrodes were placed in a corn row. Plats 1, 2, 3, 10, 11 and 12 were to

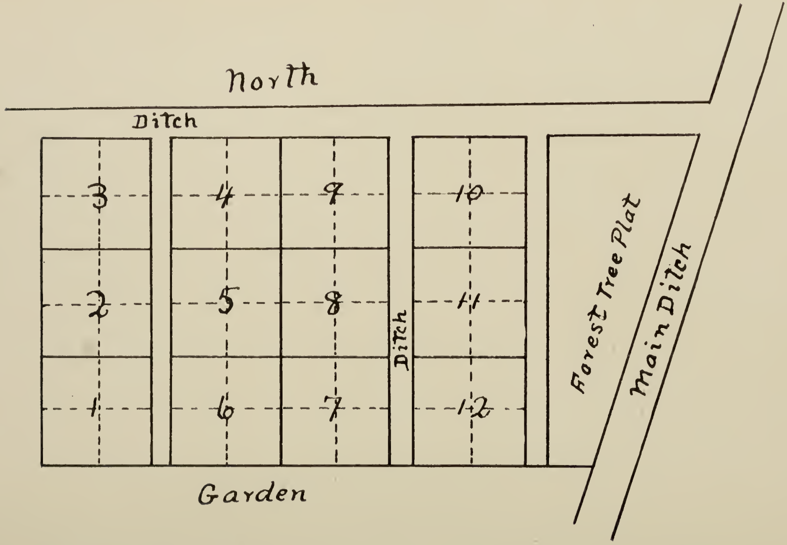
North
Ditch
Ditch
Forest Tree Plat
Main Ditch
Garden

Figure 1.

receive two irrigations during the season, the first to be applied at the time of the planting, the second at the time of shooting. Some writers claim that sub-soiling increases the power of the soil to retain moisture, and those two sets of plats, 1-3 and 10-12, were intended to test this point on this soil, plats 10-12 having been double plowed in the spring of 1899. Plats 4, 5 and 6 were to be irrigated three times, first at the time of planting; second, when the corn was showing need of water, which is usually before tasseling; and third when the grains begin to form, this being the method usually practised in the Mesilla valley. Plats 7, 8 and 9 were to receive a maximum of irrigation, which was to be oftener than on plats 4-6, probably every four weeks. These plans for irrigation were, however, not fully carried out owing to the lack of water. The experiments were further designed to test the effect of cultivation on the conservation of moisture.

Plats 3, 4, 9 and 10 were to be cultivated once each week; plats 2, 5, 8 and 11 were to be cultivated once every two weeks, and plats 1, 6, 7 and 12 once every three weeks. All cultivation was with the Planet Jr. cultivator.

MOISTURE DETERMINATIONS

The moisture determinations this year, as in 1899, were made by the methods of sampling and determining the moisture in the samples by drying, and by the electrical method devised by the division of soils of the U. S. department of agriculture.

The samples were taken the first of each month, and the readings of the soil hygrometer were taken every two days.

The results by the two methods agreed much more closely this year than in 1899, because of the exercise of more care in sampling. This season, instead of using adjustable temperature cells, the cells used the previous season were well coated with Chatterton's compound and then wrapped with insulating tape; this sealed them so well that there was very little trouble from leakage at the point where the okonite tube joins the metal cup. Their resistance was adjusted to the required amount by putting in the necessary length of okonite rod. They were then tightly stopped with rubber stoppers and these stoppers sealed in with Chatterton's compound. There was very little trouble from leakage during the season. The quantity of moisture. however, fell so low in some of the plats that it was necessary to put in other cells having a different resistance. On the whole the hygrometer method has proven quite satisfactory.

The soil physicist also made a few non-adjustable glass temperature cells which were incased in brass tubes. and which have proved quite satisfactory, being put in, used through the season, and taken up late in the fall in good condition. Most of the cells of the other form were in good condition when taken up.

CULTIVATION AND IRRIGATION

The field in which the plats were located, grew sweet potatoes, winter wheat and corn in 1899. Nothing was done to the land after the crop of 1899 was harvested (about September 25) until March of 1900. During the first week in March the ground was ploughed to a depth of from four to six inches. The winter rains, 2.18 inches from November to March, wet the ground materially. No irrigation had been given since August 15, 1899 yet the soil was very wet, in places so wet that it stuck to the plough. From March 12 to April 3 the ground was thorougly pulverized with a disc harrow, followed by the toothed harrow and smoothing board, and then marked off for planting. The land was yet quite cloddy in places. On April 14 and 15 the lateral ditches were made, and the borders between the plats, as well as the borders dividing the plats. (See Fig. 1.)

The water gave out in the main ditch about this time, and consequently the corn planting was delayed about three weeks. The corn was planted with a hand planter, on May 17 and 18, in rows running east and west. The rows were 45 inches apart and the hills about 34 inches apart in the rows, with from three to five grains in the hill. Irrigation to produce germination was given on May 19th and 20th. The germination was good and on May 28 the corn was coming up nicely all over the field, except in a portion of plat 6, where it came on later in good condition. The stand was very good and therefore no replanting was required. June the 3 to 7 the corn on all the plats was hoed in the rows and cultivated in the middles with the Planet Jr. cultivator. The ground was quite weedy, owing to the fact that the planting was delayed some time after marking off, thus giving the weeds time to make a start before the soil became dry enough for cultivation after planting and irrigating. The ground should have been cultivated and re-marked before planting; but it was feared that the flowing water in the ditch would not continue a sufficient time to allow a more careful preparation of the soil.

The Planet Jr. cultivator, the heaviest tool, with the exception of the stirring plow, that was then a part of the equipment of the Station farm, proved too light for this heavy soil, especially after the weeds had so good a start. This fact illustrates very clearly the desirability of prompt vigorous cultivation for the eradication of weeds. In addition to destroying the weeds it is desirable that the cultivation should loosen up the soil, after it becomes packed by each irrigation, in order to permit heat and air to penetrate to the roots of the growing corn.

Plats 7, 8 and 9 received their second irrigation on June 14. Plat 6 became partially flooded by water breaking over from Plat 7. The field was still quite weedy at this date, and therefore from June 14 to 30 it was hoed again. The main ditch went dry the last of June and therefore the plan of irrigation was carried out no farther. A heavy rain on the plains caused a little water to come down the ditch in the afternoon of July 4. The flow, however, lasted for only two or three hours. From a misunderstanding the north half of plats 4, 9, and 10 was irrigated instead of plats 7, 8 and 9, as outlined in the beginning. This did not affect the soil moisture results, since the electrodes were placed near the center, but within the southeast quarter of each plat; hence only the comparison of yields was interfered with by this mistake. This, however, brought out quite cleary the effects of a second and third irrigation upon the crop. Plats 4 and 10 received the first irrigation at planting time and the north half of each a second irrigation on July 4. Plat 9 received the first irrigation at the time of planting, the second on June 14th, and the north half a third on July 4. The effect of the second irrigation is shown by the yield (See table 9) on plats 7 and 8, and the effect of the third irrigation is shown by the yield on plat 9, although the yield on plat 9 is somewhat less than it would have been had the whole of the plat received water on July 4.

The relative benefit of a second and third irrigation may be more fully seen by a comparison of the yields on those plats receiving water only once during the season (at the time of planting),—plats 1, 2, 3, 5, 11 and 12; and those that received water, in whole or in part, two or three times during the season,—plats 4, 6, 7, 8, 9 and 10. Six plats that received only one irrigation gave a yield of 3104 pounds of dry matter (fodder), while the six plats that received water two and three times during the season yielded 5360 pounds of dry matter. Plate 11 further illustrates the value of a second irrigation. The portion on the right received one irrigation only and that at time of planting. The left hand portion received two irrigations during the growing season, one at the time of planting and a second on July 4. The portion receiving only one irrigation produced nothing but stover (the plant without the grain), and that of very poor quality; while the part of the plat that received two irrigations produced, not only excellent stover, but a fair crop of corn.

The corn on portions of all the plats was tasseling on July 26. Cultivation was stopped on August 15, since the corn at this date was maturing very rapidly. By September 1, a portion of many of the plats was dried up, though much of the corn remained green. A few days later the cutting was begun and was completed by September 17.

MOISTURE

It is not thought necessary to present all of the moisture data, but in Table 7 will be found enough of it to indicate the general moisture content during the season, and the marked fluctuations due to irrigation and rainfall. Table 7 also shows the marked changes in the condition of the crop.

TABLE 7—MOISTURE CONTENT AND CROP CONDITION OF THE 12 PLATS.

Date.	Plat 1.			Plat 2.			Plat 3.			Rain in inches.
	Depth.		Condition of corn.	Depth.		Condition of corn.	Depth.		Condition of corn.	
	3 to 6	15 to 18		3 to 6	15 to 18		3 to 6	15 to 18		
	per cent.	per cent.		per cent.	per cent.		per cent.	per cent.		
June 2	22.0	18.2	Good.	21.0	21.4	Good.	25.0	15.4	Good.	.04
" 9	20.4	18.2	......	16.0	20.2	......	22.6	14.4	......	......
" 13	20.2	18.2	......	14.0	19.8	......	20.4	13.8	......	......
" 15	19.4	17.8	......	13.6	19.6	......	19.2	13.6	......	......
" 20	19.0	17.4	Good.	11.6	19.0	Curling some.	16.4	13.0	Curling some.	......
July 2	16.8	15.4	Begin to curl.	11.6	18.0	Curling much.	13.0	11.0	Curling some.	......
" 4	......	......	......	......	......	......	......	......	......	.75
" 6	16.6	15.0	......	12.6	17.8	......	14.4	10.0	......	......
" 7	......	......	......	......	......	......	......	......	......	.31
" 9	17.4	14.6	......	13.0	17.6	......	14.4	9.2	......	......
" 10	......	......	......	......	......	......	......	......	......	.04
" 14	15.8	13.6	Curling some.	12.6	17.0	Curling badly.	12.8	7.0	Curling badly.	......
" 21	13.2	11.4	......	11.6	14.5	......	12.0	5.6	......	......
" 22	......	......	......	......	......	......	......	......	......	.09
" 26	......	......	......	......	......	......	......	......	......	.32

“ 28	12.0	10.0		10.8	11.8		11.2	5.4		
Aug. 2	11.0	9.0		10.4	10.8		10.8	5.4		
“ 8	10.6	8.4		10.0	10.4		10.0	5.2		
“ 9										.82
“ 10	10.4	8.4		10.0	10.2		10.0	5.2		
“ 16	10.2	8.0		10.0	10.0		10.2	5.2		
“ 24	9.6	8.0		9.4	10.6		9.6	5.2		
“ 29	9.2	7.8	Dried.	9.2	10.4	Much dried.	9.2	5.2	Nearly all dried	
Sept. 1	9.0	7.8		9.0	10.4		9.0	5.2		
“ 3										.85
“ 5	9.8	7.8		11.2	10.4		11.6	5.2		.22
“ 10	10.0	7.8		11.0	10.4		11.4	5.2		

TABLE 7.—MOISTURE CONTENT AND CROP CONDITION OF THE 12 PLATS.—Continued.

Date.	Plat 4.			Plat 5.			Plat 6.			Rain in inches
	Depth.		Condition of corn.	Depth.		Condition of corn.	Depth.		Condition of corn.	
	3 to 6	15 to 18		3 to 6	15 to 18		3 to 6	15 to 18		
	per cent.	per cent.		per cent.	per cent.		per cent	per cent.		
June 2	28.6	23.0	Good.	16.8	27.6	Good.	39.5	32.0	Good.	.01
" 9	26.0	23.0	......	12.0	25.0	......	34.0	31.0	......	......
" 13	21.8	23.0	......	11.0	21.4	......	30.0	31.0	......	......
" 15	24.4	23.0	......	9.8	19.4	......	45.0	31.4	......	......
" 20	16.8	23.4	Good.	9.6	19.0	Curling some.	37.0	31.0	Good.	......
July 2	10.5	23.4	Culing slightly.	8.0	21.0	Curling much.	21.0	29.6	Good.	......
" 4	......	......	......	......	......	......	......	......	......	.75
" 6	10.0	23.4	......	10.8	18.2	......	26.0	27.8	......	......
" 7	......	......	......	......	......	......	......	......	......	.31
" 9	9.4	23.4	......	12.0	18.0	......	26.8	27.0	......	......
" 10	......	......	......	......	......	......	......	......	......	.04
" 14	9.0	23.4	Curling very much.	9.2	17.0	Curling badly.	18.5	24.0	Curling slightly.	......
" 21	9.0	23.0	......	8.0	14.8	......	15.8	21.2	......	......
" 22	......	......	......	......	......	......	......	......	......	.09
" 26	......	......	......	......	......	......	......	......	......	.32

" 28	8.8	22.2	....	7.4	13.8	....	13.4	20.0	Curling some	....
Aug. 2	8.8	21.6	....	7.0	13.2	....	13.4	19.2	....	....
" 8	8.0	21.2	....	6.6	13.0	....	13.4	18.6	....	....
" 9	....	....	....	....	....	....	....	....	....	.82
" 10	7.6	20.8	....	6.6	13.0	....	13.4	18.6	....	....
" 16	7.2	19.8	....	7.0	12.4	....	13.0	18.2	....	....
" 24	6.8	19.6	....	6.2	12.0	....	13.0	17.6	....	....
" 29	6.8	18.4	Much dried.	5.8	11.4	Much dried.	12.8	17.4	Dried.	....
Sept. 1	6.4	18.4	....	5.4	11.2	....	12.8	17.4	....	....
" 3	....	....	....	....	....	....	....	....	....	.85
" 5	6.0	18.4	....	8.6	11.2	....	13.0	17.4	....	.22
" 10	7.4	18.0	....	8.6	11.0	....	12.8	17.2	....	....

TABLE 7—MOISTURE CONTENT AND CROP CONDITION OF THE 12 PLATS—Continued.

Date.	Plat 7.			Plat 8.			Plat 9.			Rain in inches.
	Depth.		Condition of corn.	Depth.		Condition of corn.	Depth.		Condition of corn.	
	3 to 6	15 to 18		3 to 6	15 to 18		3 to 6	15 to 18		
	per cent.	per cent.		per cent.	per cent.		per cent.	per cent.		
June 2	23.6	30.6	Good.	25.4	27.0	Good.	32.8	27.0	Good.	.04
" 9	21.0	26.6	......	20.0	22.0	......	28.4	26.4	......	......
" 13	17.8	20.0	......	18.4	16.0	......	23.0	26.0	......	......
" 15	29.6	31.4	......	30.2	34.0	......	40.3	27.0	......	......
" 20	24.2	30.2	Good.	25.4	30.5	Good.	30.4	27.0	Good.	......
July 2	15.2	25.6	Good.	14.2	20.0	Good.	18.6	22.2	Good.	......
" 4	......	......	......	......	......	......	......	......	......	.75
" 6	16.4	22.0	......	19.0	18.2	......	21.2	20.4	......	......
" 7	......	......	......	......	......	......	......	......	......	.31
" 9	15.0	20	......	19.2	17.6	......	17.4	18.8	......	......
" 10	......	......	......	......	......	......	......	......	......	.4
" 14	14.8	16.6	Curling slightly.	13.0	15.4	Begins curling,	14.8	16.4	Begins curling.	......
" 21	13.0	15.4	......	11.4	14.0	......	13.4	14.0	......	......
" 22	......	......	......	......	......	......	......	......	......	.09
" 26	......	......	......	......	......	......	......	......	......	.32

" 28	12.0	14.8	Curling much.	10.0	13.4	Curling much	12.8	12.8	Curling much.	....
Aug. 2	11.4	14.6	....	8.8	12.6	....	11.8	12.4	....	....
" 8	10.4	14.4	....	7.4	12.2	....	11.8	12.2	....	....
" 9	....	....	....	....	....	....	....	....	....	.82
" 10	13.0	14.4	....	11.4	12.2	....	11.8	12.0	....	....
" 16	11.6	14.4	....	11.0	11.8	....	11.0	11.8	....	....
" 24	10.0	14.4	....	9.0	11.8	....	10.2	11.8	....	....
" 29	8.8	14.2	About all dry.	8.0	11.6	Dried.	9.8	11.8	Nearly dried.	....
Sept. 1	8.2	14.2	....	7.6	11.4	....	9.8	11.8	....	....
" 3	....	....	....	....	....	....	....	....	....	.85
" 5	16.8	14.2	....	11.0	11.4	....	10.4	11.8	....	.22
" 10	15.0	14.2	....	10.4	11.4	....	10.2	11.8	....	....

TABLE 7—MOISTURE CONTENT AND CROP CONDITION OF THE 12 PLATS.—Concluded.

Date.	Plat 10.			Plat 11.			Plat 12.			Rain in inches.
	Depth.		Condition of corn.	Depth.		Condition of corn.	Depth.		Condition of corn.	
	3 to 6	15 to 18		3 to 6	15 to 18		3 to 6	15 to 18		
	per cent.	per cent.		per cent.	per cent.		per cent.	per cent.		
June 2	23.6	20.2	Good,	25.0	24.0	Good.	27.0	26.4	Good.	.04
" 9	22.6	20.0	....	21.8	23.6	....	23.6	26.0	....	....
" 13	21.2	20.0	....	19.6	23.2	....	21.0	25.8	....	....
" 15	20.6	20.0	....	17.8	22.8	....	20.0	25.8	....	....
" 20	20.0	19.5	Curling some.	17.8	22.0	Curling some.	18.0	25.6	Curling,	....
July 2	14.0	18.8	Curling much.	16.8	20.6	Curling much.	15.6	23.6	Curling badly.	....
" 4	....	....	....	....	....	....	....	....	....	.75
" 6	13.4	18.0	....	17.4	20.0	....	17.0	23.0	....	....
" 7	....	....	....	....	....	....	....	....	....	.31
" 9	13.4	17.4	....	17.4	19.2	....	19.0	21.8	....	....
" 10	....	....	....	....	....	....	....	....	....	.04
" 14	12.6	15.6	....	17.2	17.8	....	17.4	19.2	Curling badly.	....
" 21	10.8	14.6	....	16.6	15.4	....	13.4	17.0	....	....
" 22	....	....	....	....	....	....	....	....	....	.09
" 26	....	....	....	....	....	....	....	....	....	.32

" 28	9.8	12.2	Curling badly.	16.0	13.4	Curling some.	12.8	15.8	Curling much.	....
Aug. 2	9.2	11.5	....	15.2	12.0	....	12.2	15.4	....	....
" 8	9.0	10.8	....	14.4	11.4	....	12.2	15.2	....	....
" 9	....	....	....	....	....	....	....	....	....	.82
" 10	9.0	10.8	....	14.4	11.2	....	11.6	15.2	....	....
" 16	8.6	10.8	....	14.4	10.6	....	11.0	15.2	....	....
" 24	7.6	10.6	....	14.0	10.2	....	10.4	15.2	....	....
" 29	6.4	10.6	Dried.	13.4	10.0	Dried.	10.0	14.8	Dried.	....
Sept. 1	5.6	10.6	....	13.0	10.0	....	10.0	14.8	....	....
" 3	....	....	....	....	....	....	....	....	....	.85
" 5	9.0	10.8	....	14.8	10.0	....	9.9	14.8	....	.22
" 10	9.0	10.8	....	14.8	10.0	....	13.0	14.8	....	....

Table 8 contains a summary of the relations of the condition of the crop to the moisture present.

TABLE 8.—Relation of Soil Moisture to Wilting

Not Curling

Date.	No. of plats.	Per cent of moisture at 3-6 in.			Per cent of moisture at 15-18 in.		
		Average.	Min.	Max.	Average.	Min.	Max.
June 20..	5	27.3	19.4	30.4	27.3	17.8	30.5
July 2....	3	15.9	14.0	18.6	22.6	20.0	25.6
July 14...	....	....	....	....	....	....	....

Curling

Date.	No. of plats.	Per cent of moisture at 3-6 in.			Per cent of moisture at 15-18 in.		
		Average.	Min.	Max.	Average.	Min.	Max.
June 20..	7	15.7	9.6	20.0	20.2	13.0	25.6
July 2....	9	14.1	8	21	20.1	11	29.6
July 14...	12	13.9	9	18.5	16.9	7.0	24.0

The data given in the tables and the following discussion refers only to the southeast section of the plats, in which sections the electrodes were located.

In the plats which did not receive an irrigation after June 2 (plats 1, 2. 3, 4, 5, 10, 11, and 12) the moisture content fell throughout the season, rapidly at 3–6 inch. when there was more than 15 per cent, and more slowly when it fell below this. On plat 5 the moisture fell as low as 5.4 per cent at 3–6 inches, and plats 4 and 10 had but little more.

The moisture content at 15–18 inches fell more slowly than that at 3–6 inches, and in most cases did not go so low. On Plat 3 it fell to 5.2 per cent, and Plat 1 was nearly as low.

Plats 6, 7, 8 and 9, which were irrigated on June 14, had (at 3–6 inches) at that time from 17.8 to 30 per cent of moisture, and on the next day they had from 29.6 to 45 per cent.

This irrigation brings out some points of interest. The water capacity of plats 6 and 9 at 3–6 inches are 44.4 and 42.5 respectively; if the 45 per cent and 40.3 per cent found in these plats after the irrigation be calculated in percentage of the water capacity, they give 101.1 and 95 per cent respectively. These results indicate that the Wolff-Wahnschaffe method will give results which compare very favorably with those obtained in the field. The water capacity of plat 7 and 8 is 40.3 per cent; by the Wolff-Wahnschaffe method, if the 29.6 and 30.2 per cent or moisture found on June 15 be calculated in percentage of the water capacity, we find 73.4 and 79.4 per cent respectively, indicating that these plats were only about three-fourths saturated, at 3-6 inches, at the electrodes. This further emphasizes the fact, which has also been seen in other moisture work, that at best the distribution of an irrigation through a soil is quite uneven. This may be partially accounted for in two ways: First, variable soil conditions, some areas of the same texture allowing water to percolate more rapidly than others; and second, the land is never perfectly level, and so more water is applied in the lower places than in the higher.

Effect of Rain

Less than .5 inch of rain had no appreciable effect on the moisture content at 3–6 inches, and in no case did the rain seem to have affected the amount at 15–18 inches.

The rains affected the moisture content of the plats quite differently. The .75 inch of rain on July 4 had apparently no effect on plats 1, 4 and 10, while on the other plats it increased the moisture by from .6 to 5 per cent.

The .82 inch of rain on August 9 affected the readings on only two plats; plat 7 was raised 2.6 per cent, and plat 8, 4 per cent.

The 1.07 inches of rain on September 3–5 affected all the plats, the rise varying from .2 to 8.8 per cent. In some cases it took several days for the effects of the rain of September 3 to reach its maximum effect on the moisture at 3–6 inches.

Relation of Moisture to the Condition of the Crop

When the experiment was planned it was hoped that there was water enough to keep all of the plats in fair moisture condition, and no especial thought was given to the determination of drought limits. The work proved, however, of more value in determining drought limits than in any other direction. Had we been looking especially for drought limits the observations on the condition of the crop would have been made more in detail, especially would the condition of the stalks of corn adjacent to the electrodes have been carefully noted. The observations given in the tables were made on the quarter of the plat in which the electrodes were located, and not on the stalks of corn near the electrodes.

The amount of moisture shown by the electrodes when the corn began to curl varied considerably. The moisture at 3–6 inches seems to be of much more importance than that at 15–18 inches, and this is the more marked early in the season because the roots have not developed much at 15–18 inches. The beneficial effect of a good supply of moisture is indicated on July 2 on plat 4; here the corn is only curling slightly, with 18.5 per cent of moisture at 3–6 inches, because there is 23.4 per cent at 15–18 inches; on the other hand, this moisture below does not seem to be able to supply the plant entirely, for on July 14 we find the corn curling very much, although there is still 23.4 per cent of moisture at 15–18 inches, there being, however, but 9 per cent at 3–6 inches.

From the data in tables 7 and 8 it seems to be scarcely safe to allow the moisture to fall below 16 per cent.

After July 14 none of the plats had sufficient moisture, and several of them did not have enough after June 20.

The most marked deviation above the average is to be seen in plat 10, which was curling somewhat on June 20, when there was 20 per cent of moisture at 3–6 inches; on the other hand, plat 5 shows a greater deviation on the other side, for it had only 9.6 per cent for about the same amount of curling. This subject of drouth limits will receive further attention during the coming season.

Effects of Cultivation on the Moisture

Plates 8, 9 and 10 show the per cents of moisture at 3–6 inches on three sets of plats, platted as curves. To find the percentage of moisture on any date, follow down the vertical line of that date until it cuts the curve, then the horizontal line which intersects these two will give the per cent of moisture.

These curves are platted on the basis of the water capacity of each soil, since this gives a common basis for comparison. The rate at which the soil loses its moisture is shown by the slant of the curve. When the slant is quite steep the soils were losing moisture rapidly. When two of the curves are practically parallel it shows that they were losing at about the same rate. It will be seen that the different plats lost their moisture at quite different rates, plats 1 to 3 being the ones in which the rate was most nearly uniform, and only here after the moisture decreased to 35 per cent. A comparison of the three sets of curves shows that the dotted line which represents the plats cultivated once a week, has the steepest slope, and this indicates that these plats lost their moisture most rapidly, seeming to show that on these soils, and in this hot dry atmosphere, frequent cultivation does not tend to conserve the moisture in the soil. On the other hand, if we compare the curves of the plats which received similar treatment except subsoiling, plats 1 and 12, we find that the curves differ from each other as much as the curves of plat 1 or 12 differ from the other curves in the set. We hesitate therefore about drawing definite conclusions, but can at least say that there is no well marked benefit shown from frequent cultivation in these experiments. It seems that the rate at which soils lose their moisture is an important factor in this problem, and that the water-retaining power of soils will form an interesting line of investigation.

TABLE 9

Yield

PLATS ARRANGED IN ORDER OF YIELDS

Received one Irrigation.		Received two Irrigations.	
No. of Plat.	Yield in Pounds.	No. of Plat.	Yield in Pounds.
3	360	4	470
5	380	6	730
2	470	8	870
1	590	10	910
12	604	*9	1020
11	700	7	1360
Total on six plats	3104	Total on six plats	5360

From an inspection of table 9 it will be seen that plats 1, 3, 5, 11 and 12, which received only one irrigation during the season, are those which give the low yields, with the single exception of plat 4; while plats 6, 7, 8, 9, and 10 are those which gave the higher yields. The fact that the yield does not always correspond with the number of irrigations given and with the moisture present in the soil as shown by the hygrometer, indicates that the soil varies in spots. Another evidence of the spotted condition of the soil, which may be due to various causes, is shown in the uneven growth of the corn. The same plat, within the distance of a few feet, maturing some corn 2 feet and some 7 feet high.

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* One half of this plat received three irrigations.

SUMMARY AND CONCLUSIONS

1. The moisture content of irrigated land is apt to vary within wide limits.

2. The results of this season's work indicate that when the moisture in this soil falls below a fairly definite limit the corn begins to cure. This limit lies near 20 per cent, calculated on dry weight of soil, or about 50 per cent of the water capacity of the soil, at 3-6 inches.

3. The crop showed very unequal growth within short distances, the reasons for which we are not yet able to explain.

4. The results indicate that under the climatic conditions which prevailed during last season at least three irrigations are necessary to produce a crop of corn, and that the late irrigation showed more marked effect than the early irrigations.

5. The cultivation (as practiced this season) does not seem to have had the desired effect in conserving moisture in this soil.

6. Good germination is readily produced by irrigating to produce germination after planting, even when the water is quite muddy.

7. Subsoiling had apparently no effect either on moisture content or yield.

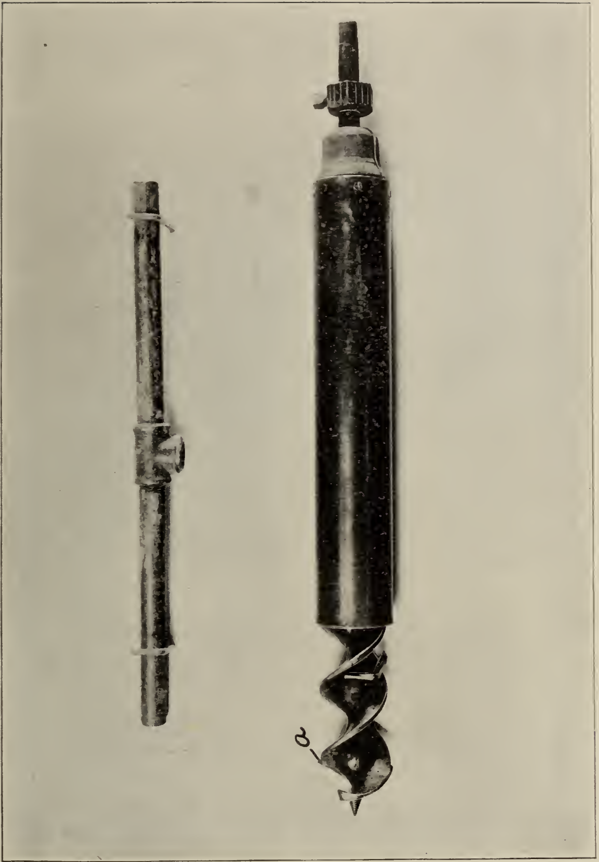


PLATE 1—Soil Auger

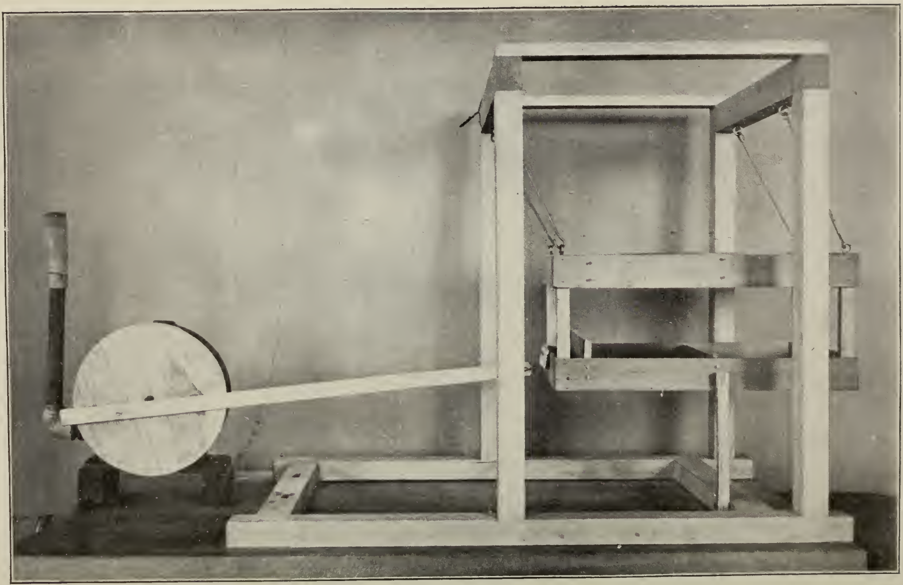
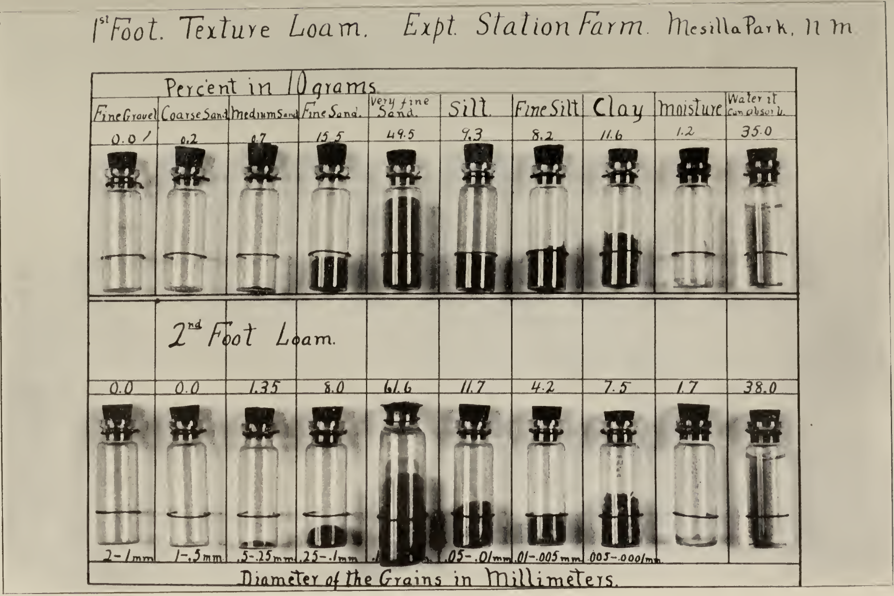


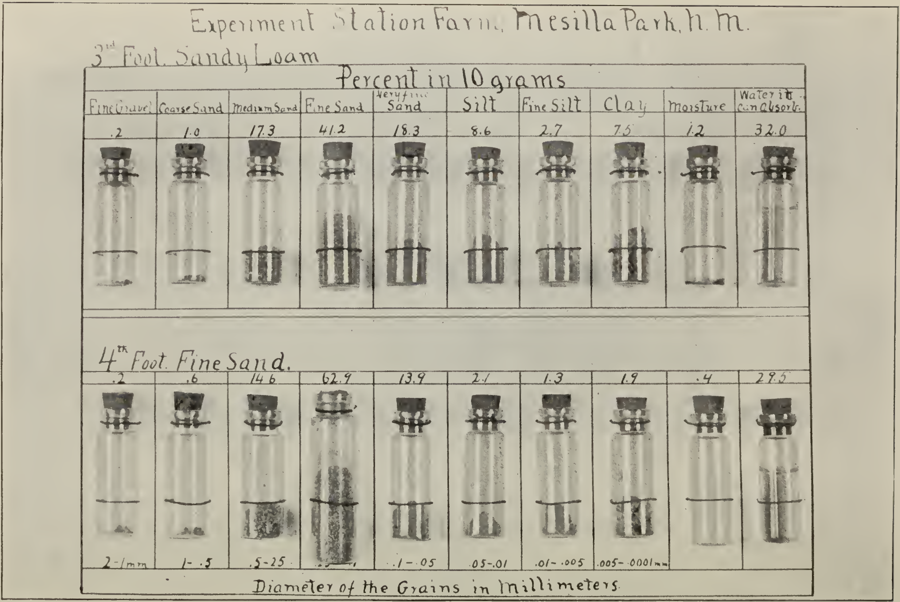
PLATE 2—Water Motor and Shaker



1st Foot. Texture Loam. Expt. Station Farm. Mesilla Park, N M.

Percent in 10 grams									
Fine Gravel	Coarse Sand	Medium Sand	Fine Sand.	Very fine Sand.	Silt.	Fine Silt	Clay	moisture	Water it can absorb.
0.01	0.2	0.7	15.5	49.5	9.3	8.2	11.6	1.2	35.0
2nd Foot Loam.									
0.0	0.0	1.35	8.0	61.6	11.7	4.2	7.5	1.7	38.0
2-1mm	1-.5mm.	.5-.25mm.	.25-.1mm	.1[illegible]	.05-.01mm	.01-.005mm	.005-.0001mm.		
Diameter of the Grains in Millimeters.									

PLATE 3



Experiment Station Farm, Mesilla Park, N. M.

3rd Foot. Sandy Loam

Percent in 10 grams

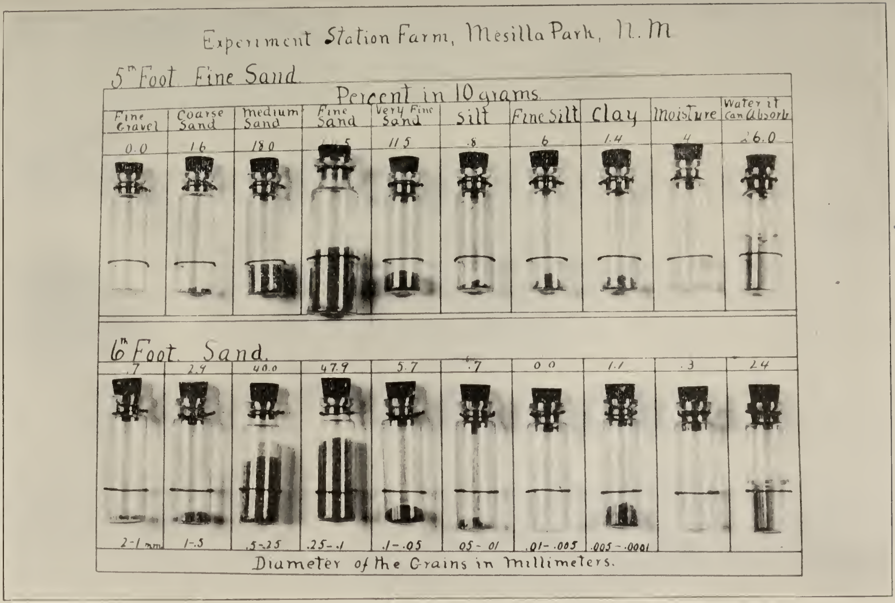
Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Fine Silt	Clay	Moisture	Water it can absorb.
.2	1.0	17.3	41.2	18.3	8.6	2.7	7.5	1.2	32.0

4th Foot. Fine Sand.

Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Fine Silt	Clay	Moisture	Water it can absorb.
.2	.6	14.6	62.9	13.9	2.1	1.3	1.9	.4	29.5
2-1mm	1-.5	.5-25	[illegible]	.1-.05	.05-.01	.01-.005	.005-.0001mm		

Diameter of the Grains in Millimeters.

PLATE 4



Experiment Station Farm, Mesilla Park, N. M

5th Foot Fine Sand.

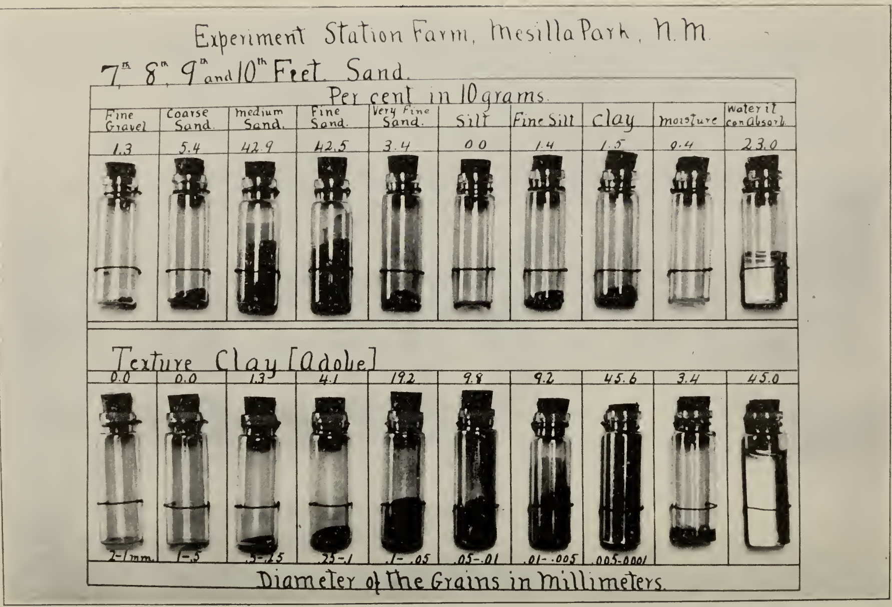
Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Fine Silt	Clay	Moisture	Water it can Absorb
Percent in 10 grams.									
0.0	1.6	18.0	5	11.5	.8	6	1.4	4	26.0

6th Foot Sand.

Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Fine Silt	Clay	Moisture	Water it can Absorb
.7	2.9	40.0	47.9	5.7	.7	0.0	1.1	.3	2.4
2-1 mm	1-.5	.5-.25	.25-.1	.1-.05	.05-.01	.01-.005	.005-.0001		

Diameter of the Grains in Millimeters.

PLATE 5



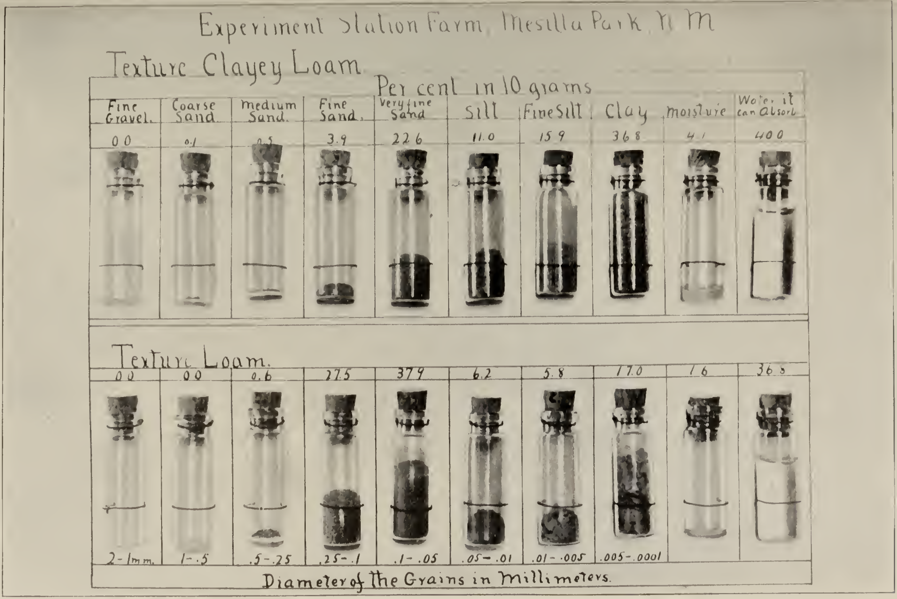
Experiment Station Farm, Mesilla Park, N.M.

7th 8th 9th and 10th Feet Sand.

Per cent in 10 grams.

	Fine Gravel	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt	Fine Silt	Clay	Moisture	Water it can absorb.
7th 8th 9th and 10th Feet Sand.	1.3	5.4	42.9	42.5	3.4	0.0	1.4	1.5	0.4	23.0
Texture Clay [Adobe]	0.0	0.0	1.3	4.1	19.2	9.8	9.2	45.6	3.4	45.0
Diameter of the Grains in Millimeters.	2-1 mm.	1-.5	.5-.25	.25-.1	.1-.05	.05-.01	.01-.005	.005-.0001		

PLATE 6



Experiment Station Farm, Mesilla Park, N. M.

Texture Clayey Loam.

Per cent in 10 grams

Fine Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very fine Sand.	Silt	Fine Silt	Clay	Moisture	Water it can Absorb
0.0	0.1	0.5	3.9	22.6	11.0	15.9	36.8	4.1	40.0

Texture Loam.

Fine Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very fine Sand.	Silt	Fine Silt	Clay	Moisture	Water it can Absorb
0.0	0.0	0.6	27.5	37.9	6.2	5.8	17.0	1.6	36.5
2-1mm.	1-.5	.5-.25	.25-.1	.1-.05	.05-.01	.01-.005	.005-.0001		

Diameter of the Grains in Millimeters.

PLATE 7

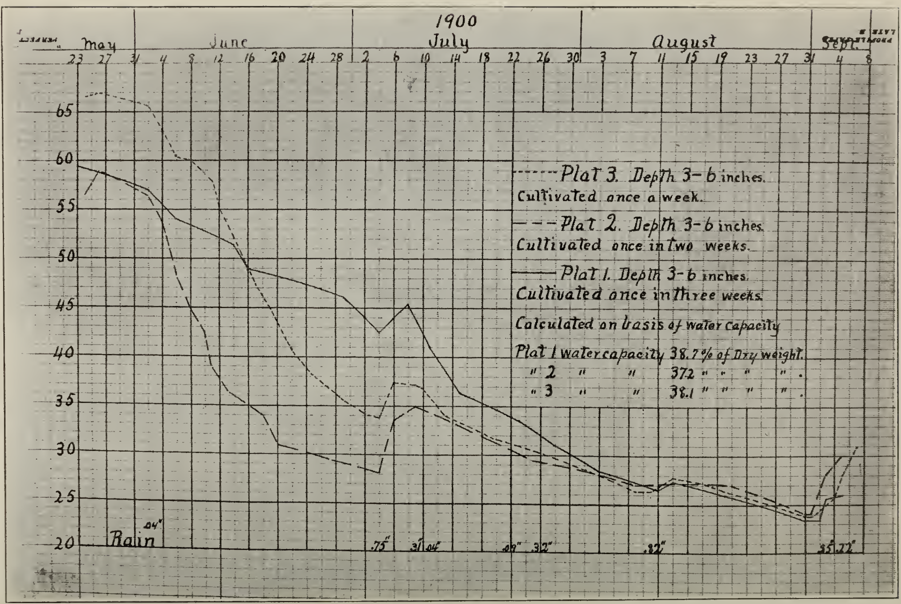

1900
May
June
July
August
Sept.
23
27
31
4
8
12
16
20
24
28
2
6
10
14
18
22
26
30
3
7
11
15
19
23
27
31
4
8
65
60
55
50
45
40
35
30
25
20
-------Plat 3. Depth 3-6 inches.
Cultivated once a week.
— — — Plat 2. Depth 3-6 inches.
Cultivated once in two weeks.
———— Plat 1. Depth 3-6 inches.
Cultivated once in three weeks.
Calculated on basis of water capacity
Plat 1 water capacity 38.7% of Dry weight.
" 2 " " 37.2 " " " ".
" 3 " " 38.1 " " " ".
Rain
.04"
.75"
.31
.04"
.09"
.32"
.82"
.35
.22"

PLATE 8

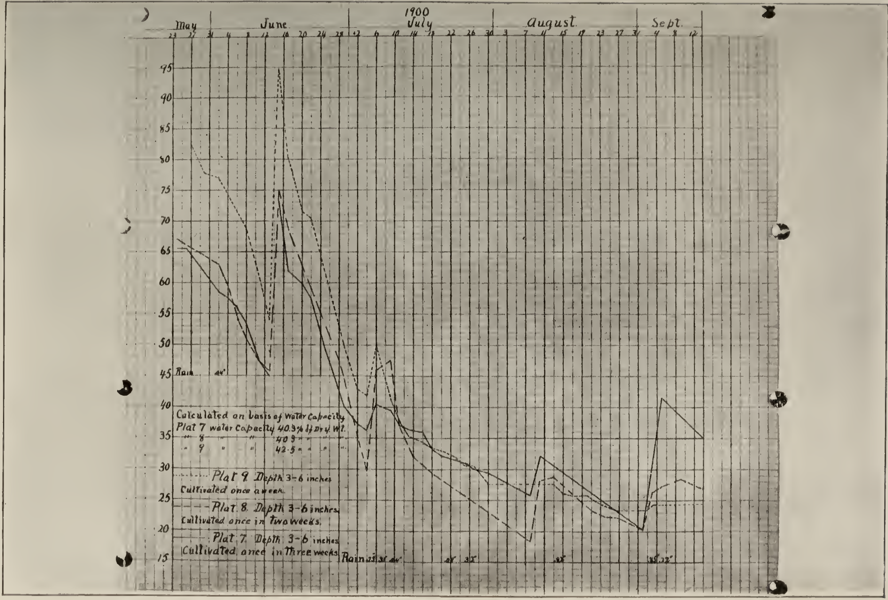

1900
May
June
July
August
Sept.
23
27
31
4
8
12
16
20
24
28
2
6
10
14
18
22
26
30
3
7
11
15
19
23
27
31
4
8
12
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
Rain .44
Calculated on basis of Water Capacity
Plat 7 water Capacity 40.3% of Dry Wt.
" 8 " " 40.9 " " "
" 9 " " 42.5 " " "
Plat 9 Depth 3-6 inches
Cultivated once a week.
Plat. 8. Depth 3-6 inches
Cultivated once in two weeks.
Plat 7. Depth 3-6 inches
Cultivated once in three weeks.
Rain .25 .31 .44
.05 .35
.15
.35 .12

PLATE 9

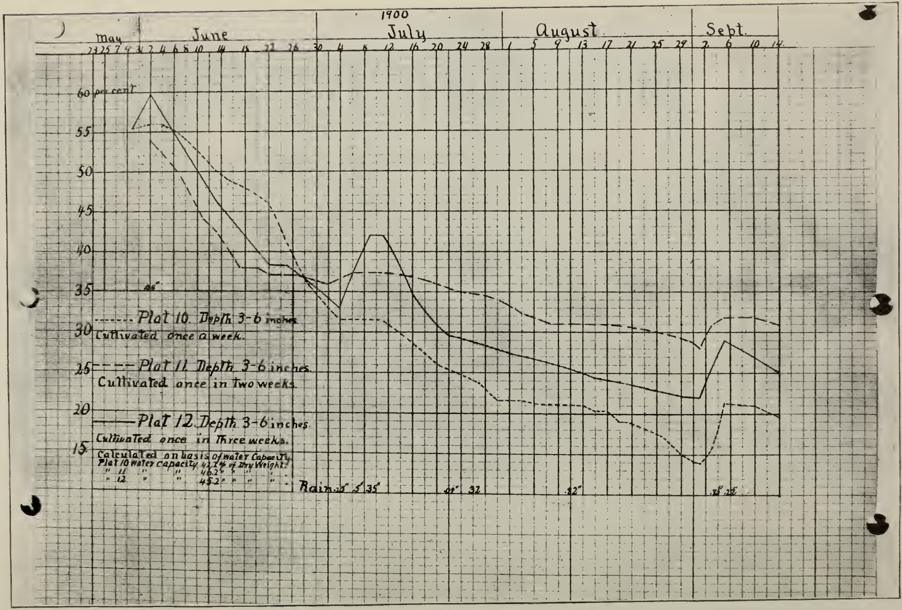
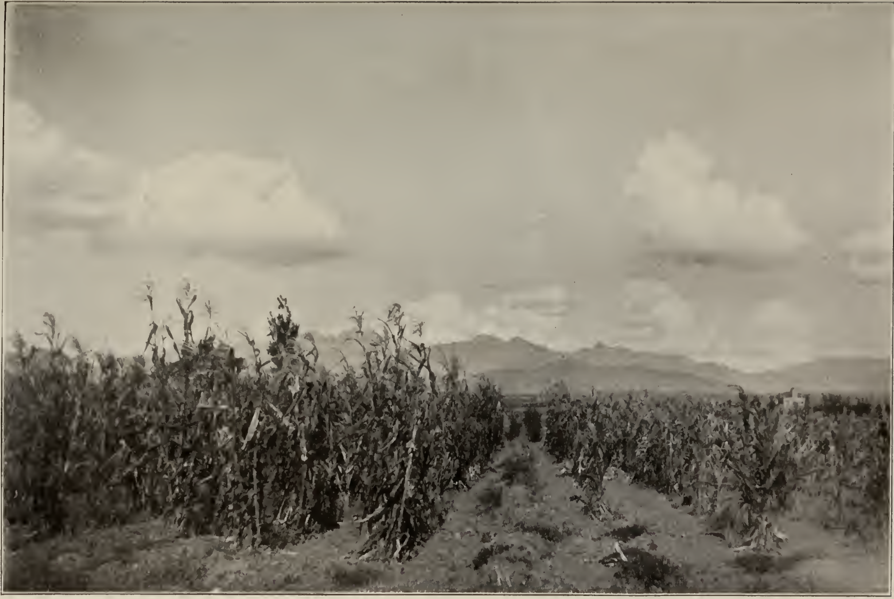

1900
May
June
July
August
Sept.
23 25 7 9 31 2 4 6 8 10 14 18 22 26 30 4 8 12 16 20 24 28 1 5 9 13 17 21 25 29 2 6 10 14
60 per cent
55
50
45
40
35
30
25
20
15
.04"
------ Plat 10. Depth 3-6 inches.
Cultivated once a week.
— — — Plat 11. Depth 3-6 inches.
Cultivated once in two weeks.
——— Plat 12. Depth 3-6 inches.
Cultivated once in three weeks.
Calculated on basis of water capacity.
Plat 10 water capacity 42.2% of dry weight.
" 11 " " 46.2" " " "
" 12 " " 45.2" " " "
Rain .25" .5" .35"
.01" .32
.42"
.35" .25"

PLATE 10



Two Irrigations PLATE 11 One Irrigation

N.M.)
1
39

BULLETIN NO. 39 MAY, 1901

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

ORCHARD NOTES

1. Apricot
2. Cherries
3. Plums
4. Quinces
5. Figs
6. Pruning Back the Peach

BY

FABIAN GARCIA

The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others so far as the editions printed will allow.

SANTA FE, N. M:
NEW MEXICAN PRINTING COMPANY
1901

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INTRODUCTION

When the Agricultural Experiment Station was established, one of the principal lines of work taken up by the Division of Horticulture was a variety test of fruits. This was probably due to the great need of information regarding varieties best adapted to our conditions and best cultural methods. It is true that most of the orchard fruits have been grown more or less throughout the territory for a number of years; but they have been, in most cases, seedlings, which are, as a rule, of inferior quality and unlike the parent variety.

Lack of available information on this subject, within the territorial limits, has been the cause of many mistakes in the selection of varieties of fruit, by people who have planted orchards of the leading varieties grown in other states. It has been found that some of the leading varieties grown in the eastern states are of little or no value here. For example, among the plums, the Japanese varieties are almost worthless in New Mexico; yet many trees of some varieties of this group have been planted by people, thinking they would do as well here as in other states. Many late peaches of standard merit in the east fail here, such as Mountain Rose and Mrs. Bret.

We must find out the varieties of fruit best adapted to the conditions of the territory; and the demand for this information is growing as population increases. It is hoped that the information contained in the following pages may prove useful to people interested in questions of fruit growing. In this bulletin results of the work with apricots, cherries. plums, quinces and figs are given. In addition to this the effects of thinning the plum, and the severe pruning of the peach are discussed. In the preparation of the bulletin valuable information was secured, by correspondence, from different sections of the territory regarding the adaptability of the apricot, cherry, and plum.

APRICOTS

The apricot is like the peach in some respects, while in others it is like the plum. It resembles the former in flavor, in the shape of its fruit, and in being sometimes downy; but in the broad leaves of the trees and smooth stone of the fruit it is more like the plum. It is as hardy as the peach, and under the same general cultivation and care, the apricot may be expected to grow where the peach grows. The apricot is not grown so extensively as the peach. In California, however, where it is one of the leading commercial fruits, it has been extensively planted, owing to the thriftiness of the tree and the excellence of its fruit and its general adaptation to the climate. The apricot is naturally a rapid and vigorous grower, usually of an upright and spreading character, with a somewhat uniform head, making it one of the most beautiful orchard trees.

In New Mexico, as in other places where the apricot grows, it has given evidence of a longevity greater than that of other orchard trees, with the possible exception of the pear. Some very old seedling apricot trees can still be found growing in some of the Mexican home grounds, especially in the Mesilla Valley. In this valley these seedlings, as well as named varities, as a rule, bloom heavily and early. A large part of the blooms is destroyed by frost and sometimes all the blooms are injured. A fair crop of fruit is borne by the trees once in about five or six years. The fruit is small and somewhat dry, but fairly good in quality. Since the introduction of the English and French varieties the seedling trees have become less and less common.

The ideal soil generally recommended for the apricot is one which is deep, dry, and loamy. However, the apricot trees growing in thedifferent parts of the Experiment Station orchard, in soils of widely different texture (passing from a light loam to an adobe that is almost impenetrable to water), show no material difference in growth. And they are the largest and healthiest trees in the orchard. They seem to have no preference among our soils.

Like the Japanese plums and many of the late peaches, apricots are not regular nor heavy bearers, on account of the blooms and young fruit being destroyed by the spring frosts, which are sure to come, and which often prove fatal to the whole crop. These late spring frosts are the most serious drawback to the successful fruiting of the apricot in New Mexico. Apricots bloom earlier even than late peaches.

Out of twenty varieties of apricots which were planted in 1891 and '92 in the Experiment Station orchard, to test their adaptability to the local conditions, sixteen have bloomed and fruited, in a limited way, one or more years during the test of the past six years. During the test a record of the blooming and ripening periods has been kept, and descriptions have been made of each variety whenever there was fruit available for the purpose. By referring to table I, it will be seen that some of the apricots in the list have fruited nearly every year, but only bore a light crop. None of the varieties have, as yet, produced what is considered a commercial crop.

The apricot fruit buds seem to be very easily stimulated into growth by our early warm spells in January and February. It has been observed in the Experiment Station orchard, that, in many cases, the fruit buds swell so early in the season that a large per cent of them are injured before they open. It has also been observed that after the true blooming period is over, there are sometimes found a few scattering blossoms on the trees, and it is believed that in many cases the fruit that is produced is more a result of the second blooming than of the few blooms that may have escaped the frosts. Generally the varieties bloom when there is yet a great deal of danger from frost; and frequently there is some very cold weather about the time the varieties are in full bloom. These cold spells seemingly tend to temporarily stop further blooming. Of course, the effect on the blooms and very advanced buds is undoubtedly fatal, as is seen by the parched petals and blackened and shriveled pistils. This partial check upon the activity of the tree would induce the less developed or even dormant fruit buds to remain in such condition until the activities of the tree are again resumed, when the undeveloped buds are stimulated into growing and blooming. It seems reasonable to believe that if the main crop of buds and blooms were not destroyed this second blooming would not occur. Once in a while a large per cent of blooms escape the frosts and a large crop of fruit is set, and everything seems safe; but even then one may be disappointed. These apricots sometimes grow to be twice as large as a pea and then begin to drop. They usually drop after the danger of frost is over, indicating that the fruit must have been injured by frost after it had attained some size; otherwise it would have dropped earlier.

The blooming period of the apricot, like that of the peach, is not constant from year to year. It depends to a great extent on the character of the winter; if mild we may expect an earlier blooming of the trees. And even the time of blooming among the varieties themselves is somewhat variable from year to year. Some varieties have not bloomed every year. This is seemingly due to the fact that all the buds have been injured. At other times they open up though the pistil is dead.

In 1895 (see Table I) fourteen varieties bloomed. One, the Bungouma, which is an exceedingly early bloomer, was in full bloom by February 25th. The Gold Dust, the second earliest bloomer, came out March 11th. Eight varieties bloomed during the beginning of the third week in March, while only four were comparatively late, blooming March 26th. Eight of the varieties ripened some fruit, while six did not bear at all. None of the varieties that bore, however, produced a heavy crop, and all of them bloomed the second time, having a few scattering blossoms on April 8th. On the whole the spring of 1895 was quite favorable.

In contrast to this, the spring of 1896 was very unfavorable as all the fruit was killed. January and February were unusually warm; thus the apricot trees were stimulated into growth and blooming early. The trees bloomed from five to ten days earlier than in 1895. The Bungouma was in bloom February 19th, and all other varieties that bloomed were out about the last of the first and beginning of the second week in March. During March 17, 18, 19, the weather turned very cold, and the temperature dropped to 20° F on the 18th. Just one month later, on April 18th, the last killing frost occurred and any apricots that had escaped the previous freezes were at that time destroyed. The last killing frost was exceptionally late and severe. No tender unprotected fruit could have stood nine degrees of freezing weather.

During the spring of 1897 more varieties bloomed and somewhat later than in the previovs season; most of them being in bloom during the second week in March, while the Royal and Gold Dust were out the first week in March, and the Bungouma on February 20th. Eight varieties of those that bloomed produced only a light crop. The Moorpark, Prieb, Royal, and Skobeloff had a few blooms the second time, April 12th.

With the exception of the Prieb, all bloomed in 1898, and, on the whole, earlier than in 1897. All bloomed during the first or about the beginning of the second week in March, excepting the Budd, which bloomed March 16th and the Bungouma February 23rd. The spring of 1898 was not very favorable for the fruiting of the apricot. The Blenheim, Luizet, St. Ambroise and Skobeloff, the only varieties which bore this season, had only a few fruits. About a week after most of the trees had been in full bloom the weather turned quite cold, and on March 24th the minimum degree of heat registered was 12° F., 20° below the freezing point—which temperature was too severe for opened blooms and the newly set fruit to withstand. No second blooming was observed this season.

The following table gives the dates of blooming and ripening, and also the comparative yields for the past six years.

TABLE I

Name.	1895.			1896.*	1897.		
	Date of blooming.	Date of ripening.	Crop.	Date of blooming.	Date of blooming.	Date of ripening.	Crop.
Bungouma	Feb. 25	...	...	Feb. 19	Feb. 20	...	...
Budd	Mar. 26	...	...	...	...	...	...
Blenheim	“ 16	June 30	Very light.	Mar. 8	Mar. 16	June 26	Light.
Catherine	“ 26	...	...	...	“ 13	...	...
Early Rivers	...	...	...	Mar. 8	“ 15	...	...
Gold Dust	Mar. 11	“ 22	Very light.	...	“ 4	...	...
Hemshirke	“ 16	July 3	Very light.	Mar. 10	“ 11	...	...
Large Early	“ 18	...	...	“ 12	“ 15	...	...
Luizet	“ 16	...	...	“ 9	“ 11	June 28	Light.
Montgamet	“ 16	...	...	“ 9	“ 10	...	...
Moorpark	“ 18	July 3	Light.	“ 8	“ 10	July 2	Light.
Newcastle	...	...	...	...	“ 9	June 18	Light.
Prieb	“ 26	June 22	Light.	...	“ 10	“ 24	Light.
Royal	“ 16	July 2	Light.	“ 9	“ 8	July 2	Light.
St. Ambroise	“ 26	June 22	Light.	...	“ 14	June 27	Light.
Skobeloff	“ 16	“ 30	Light.	“ 11	“ 10	“ 28	Light.

*All the crop was destroyed by the severe freeze of April 18.

1898.			1899.			1900.		
Date of blooming.	Date of ripening.	Crop.	Date of blooming.	Date of ripening.	Crop.	Date of blooming.	Date of ripening.	Crop.
Feb. 23	....	....	Mar. 1	June 8	Very light.	Feb. 24	June 4	Very light.
Mar. 16	....	....	" 15	....	....	Mar. 9	....	....
" 5	June 24	Light.	" 15	....	....	" 8	June 18	Light.
" 10	....	....	" 18	....	....	....	....	....
" 10	....	....	" 20	....	....	Mar 10	....	....
" 2	....	....	" 8	June 10	Very light.	" 5	June 8	Very light.
" 8	....	....	" 13	" 26	Light.	" 12	" 25	Light.
" 14	....	....	" 21	" 20	Light.	" 17	" 21	Medium.
" 9	June 26	Light.	" 15	....	....	" 10	" 18	Light.
" 10	....	....	" 15	....	....	" 10	" 18	Very light.
" 7	....	....	" 19	June 29	Light.	" 8	" 22	Medium.
" 5	....	....	" 15	....	....	" 16	" 6	Light.
....	....	....	" 25	....	....	" 19	....	....
Mar. 5	....	....	" 19	June 30	Light.	" 7	June 23	Medium.
" 10	June 24	Light.	" 18	" 18	Light.	" 12	" 17	Light.
" 11	" 26	Light.	" 15	" 25	Light.	" 12	" 25	Light.

In 1899 all the varieties bloomed, and on the whole the blooming period was comparatively late; but even in this season only eight varieties fruited, and the Royal alone bore more than a light crop. The Bungouma bloomed March 1st, and for the first time during the test it ripened some fruit. On five trees there were not more than a dozen apricots. The Gold Dust had a few scattering blooms on April 8th.

All, except the Catherine, bloomed in 1900, the time of blooming being, in some cases, considerably earlier than in the previous year; but, notwithstanding this fact, there were twelve varieties that fruited—a larger number than for any other year—and each one produced more fruit than usual, although only the Large Early and Moorpark had a fair crop. This was the most favorable spring, by reason of the absence of severe late frosts that had been experienced during the test.

Apricots are not extensively grown throughout the territory, although as far as growth and vigor are concerned they seem to be perfectly adapted to this climate and altitude. The following, the writer had condensed from the answers to a circular letter addressed to several of the principal fruit growers in the different fruit growing districts of the territory, asking for information regarding the adaptibility of the apricot in their respective districts:

At Albuquerque and vicinity the apricot trees thrive, but they bloom too early to escape the late frosts, and as a rule only a few fruits are set. It is also reported that a good crop is set once in about every five years. The Russian varieties, such as the Gibbs and Budd, seem to be the best bearers and most popular. Further north and at Santa Fe apricot trees thrive also; it is claimed that there are seedling trees in Santa Fe known to be over two hundred years old. The Royal and Moorpark are the two varieties most extensively planted. Usually the crop of blooms is partially injured and occasionally the whole crop is destroyed by the frosts. It is reported that once in about every three years there is a crop on the trees. At Las Vegas apricots are reported as not being grown, while in the Pecos Valley, at Roswell and Carlsbad (formerly Eddy), the apricot is considered of little or no value on account of its too early blooming, though the trees grow vigorously.

As a commercial fruit the apricot in New Mexico may be said to be of little or no importance at present. From all the data at hand it is believed that apricot culture will not assume commercial proportions for reasons already stated; although it can be grown for home use, as heretofore. Many of the seedling apricots seem to resist cold better than the improved varieties; this is indicated by the presence of a crop on the trees, when the introduced kinds bear little or no fruit. Here, it may be in place to suggest that there is a field for plant breeding investigations with the seedling apricots. Something might be done to try to produce a late blooming apricot by raising some seedlings as a basis for work. In this connection it might be said that a late ripening peach that blooms late would be very desirable for this climate. If the late blooming qualities of the Alexander could be combined with the good qualities of the Elberta, Cothers. or Bequtt's free, it would be a valuable addition to the fruit industry of the territory.

Neither the apricot tree nor fruit, so far, has any serious insect or fungus enemies in New Mexico. The curculio, which is the most serious enemy of the apricot in the east, has not been observed on any of the varieties growing in the Experiment Station orchard, and has not been reported from any section of the territory; indicating that, if present at all, it is not so, as yet, in harmful numbers.

None of the varieties tested in the station orchard can be recommended for commercial planting, simply because they are uncertain bearers, as a result of the fruit buds, blooms and young fruit being constantly subjected to frost injury. However, the following varieties may be planted for home use: Blenheim, Moorpark, Royal. St. Ambroise, Luizet, New Castle and Large Early. (See plate I). Gold Dust and Bungouma should under no consideration be planted.

Descriptions of Varieties

Bungouma—Size medium, roundish oblong; cavity slightly ribbed, shallow, narrow; suture distinct; apex smooth, slightly compressed; color golden, dotted with small light dots; flesh firm, somewhat dry, acid, orange in color, poor in quality; stone large, cling. Tree upright, somewhat spreading; it is exceedingly early bloomer. Discarded.

Blenheim.—Size medium, oval; cavity deep; suture distinct; apex slightly compressed; skin orange with few scale-like spots; flesh deep yellow, firm, moderately dry, free from the oval stone; quality good. Tree vigorous, roundish, and with somewhat spreading head.

Gold Dust—Size medium, roundish oblong; cavity narrow, deep; distinct suture; apex slightly ribbed and compressed; color deep orange, few small light dots; flesh deep orange, juicy, slightly acid, free from the large dark stone; quality fair. Tree medium size, irregularly spreading, with brownish red bark; it is a very early bloomer. Discarded.

Hemshirke—Size medium, round flattish oblate; cavity rough, shallow, slanting; suture distinct; compressed apex; color orange with a reddish cheek; flesh orange, juicy, sprightly, free from the large stone; quality good. Tree vigorous with an even roundish head.

Large Early—Size medium, somewhat oblong and compressed at apex; cavity shallow, slanting, ribbed; suture barely outlined; color greenish overlaid with yellow, many specimens having a red cheek; surface somewhat rough; flesh creamy white, dry, firm, slightly clinging to large flattish stone; quality fair. Tree very vigorous, tall with a tendency to spreading.

Luizet—Size large, roundish oval with a slightly compressed apex; cavity deep, ribbed, slanting; suture distinct, deepening toward base; surface somewhat rough; color orange, many specimens having a red cheek; flesh orange, firm, slightly clinging to the stone; quality good. Tree vigorous with a uniform roundish head.

Montgamet—Size large, ovate, flattened toward the full apex; cavity deep, abrupt; suture distinct; color deep yellow; flesh deep yellow, firm, moderately juicy, parting freely from the large flat stone. Tree vigorous, spreading with a round head.

Moorpark—Size large, roundish, being compressed at the apex; cavity shallow, slanting; barely distinct suture; color deep yellow to orange, in some cases having a russet appearance; flesh orange, sweet, juicy, rich, parts freely from the roundish, flat stone. Tree vigorous and large.

New Castle—Size medium, roundish oblate with a slightly flattened apex; cavity wide and deep; suture barely distinguishable; color deep yellow, many specimens having a red cheek; flesh deep yellow, tender, sweet, juicy, adhering to the large stone; quality excellent. Tree vigorous, spreading.

Prieb—Size small, roundish oval with a flattened apex; suture shallow deepening toward both extremities; cavity wide and deep; color lemon yellow; flesh yellowish white, firm, dry, sweet, parting freely from the roundish oval stone. Tree medium size and fairly good grower.

Royal—Size medium, roundish oval, slightly flattened at apex; cavity moderately wide and deep; suture shallow; color pale orange faintly tinged with red; flesh pale orange, juicy, sweet, firm, rich. Tree vigorous, spreading.

St. Ambroise—Size large, ovate, flattening rapidly toward the slightly compressed apex; cavity shallow and narrow; suture distinct, one side being slightly higher; color pale orange; flesh pale orange, firm, sweet, quite dry, fibrous, parts readily from the large stone; quality very good. Tree vigorous, spreading with a uniform rounded head.

Skobeloff—Size small, roundish oblate with a flattened apex; cavity deep and wide; suture distinct, deepening at base; color yellow with a reddish cheek; flesh yellow, rather dry, sweet. Tree vigorous, tall, rather spreading.

CHERRIES

Cultivated cherries are usually divided into two general classes, the sweet and the sour, and these have probably come from two European species, *Prunus Avium, Linn.*, producing the sweet cherries, and *Prunus Cerasus, Linn.*, producing the sour cherries. The former type is characterized by large, erect and tall-growing trees; fruit red, yellow or black, mostly heart-shaped or pointed and generally sweet. The groups known as Hearts, Bigarreaus, and Dukes are included in this type; and as representatives of it and the three groups respectively, may be mentioned the varieties Governor Wood and Black Tartarian, Windsor and Napoleon, May Duke and Reine Hortense. The sour cherries are readily recognized by a low, round headed, and spreading tree; fruit roundish and generally sour. The groups known as Morellos and Amerelles belong to the sour cherries; and as representatives of this type and the two groups respectively, may be mentioned the varieties English Morello and Louis Phillippe, Early Richmond and Montmorency. As a rule the sour cherries are the later in ripening and the hardier of the two types.

In New Mexico the sour cherries predominate. They seem to be better adapted to our dry and sunny climate than the sweet varieties. It has been shown that the sour cherries are good and regular bearers; on the other hand the sweet varieties have proven of less value. In the northern portion of the territory the crop of the sour cherries is occasionally reduced somewhat by frosts. The sweet cherries in this section as well as in the southeastern part of the territory are reported as being very materially injured by frosts. In the Experiment Station orchard the sweet cherries bloom late enough, in most cases, to escape frost injury, but as a rule they set little or no fruit. All parts of the territory are not equally adapted to cherry growing. The same varieties seem to bear better fruit in the northern part, where it is cooler and where the relative humidity is greater, than in the south central part, where the dry atmosphere and great heat seem to influence the size and quality of the fruit somewhat. Plant growth is necessarily dependent upon the climatic conditions in any section. The central and northern part of the territory seems well adapted to the development of the fruit under consideration. Last summer, on his trip into the Animas Valley, Professor Vernon found cherries equal to, if not finer than, those grown in the central states.

The following is a summation of the replies from correspondents in the territory in regard to the cherry: In and around Albuquerque the sour cherries are a success. These are generally late bloomers and sure bearers. The Early Richmond is the variety most extensively grown. In Santa Fe the cherries are reported to be very profitable. The sour cherries are the best adapted, as they, in most cases, escape frost injury and bear a full crop every other year. The Early Richmond, English Morello and Montmorency are the principal varieties planted. The sweet cherries are unsatisfactory on account of blooming too early. At Las Vegas the sour cherries are the best, and, as a rule, they bear a full crop two years in every three. Montmorency, English Morello, Early Richmond and Ostheim are reported among the best varieties grown. In the Lower Pecos Valley, at Roswell and Carlsbad, the sour cherries thrive and bear nearly every year. The Early Richmond, English Morello, and Montmorency are among the varieties principally grown.

The following table gives the dates of blooming and ripening and also the comparative yield for the last six years of the cherries grown in the Experiment Station orchard.

TABLE II.

Name	Group.	1895			*1896	1897		
		Date of Blooming.	Date of Ripening.	Crop.	Date of Blooming.	Date of Blooming.	Date of Ripening.	Crop.
Abesse	Sweet	....	....	....	....	April 12	....	....
Black Tartarian	Sweet	April 15	....	....	April 1	....	....	....
Bessarabian	Sweet	Not Reco'd	June 13	Very Light	April 6	....	....	....
Belle Magnifique	Sweet	April 15	June 27	Very Light	....	April 16	....	....
Centennial	Sweet	....	....	....	....	April 5	....	....
Early Rivers	Sweet	....	....	....	....	April 4	....	....
Early Richmond	Sour	April 21	May 29	Full	April 10	April 17	May 24	Full
Esel Rirsche	Sweet	April 15	May 21	Full	April 6	April 12	May 20	Full
Gov. Wood	Sweet	April 2	....	....	Mar. 31	April 9	May 26	Light
Griotte Imperial	Sour	April 21	June 12	Very Light	....	April 20	....	....
May Duke	Sweet	April 15	May 27	Very Light	April 1	April 6	May 25	Light
Napoleon	Sweet	April 8	....	....	Mar. 28	April 1	....	....
Orel	Sour	....	....	....	....	April 17	....	....
Ostheim	Sour	April 15	....	....	April 6	April 12	June 9	Light
Olivet	Sweet	April 15	....	....	....	April 16	....	....
Sklanka	Sour	....	....	....	....	April 15	May 25	Light
Windsor	Sweet	....	....	....	Mar. 30	April 10	May 20	Light
Unknown	Sour	April 8	Not Reco'd	....	Mar. 31	April 16	June 7	Full

*All the crop was destroyed by the severe freeze of April 18.

1898			1899			1900		
Date of Blooming.	Date of Ripening.	Crop.	Date of Blooming.	Date of Ripening.	Crop.	Date of Blooming.	Date of Ripening.	Crop
April 19	....	......	....	....	....	April 22	....	....
....	....	......	April 16	....	....	April 9	May 26	Light.
....	....	......	....	....	....	....	....	....
April 18	June 13	Light	April 21	June 18	Light	April 19	June 21	Medium.
April 4	....	......	....	....	....	....	....	....
April 4	....	......	April 12	....	....	April 8	....	....
April 19	May 28	Full	April 15	June 2	Medium	April 17	June 3	Full
April 11	May 23	Full	April 14	May 18	Full	April 12	May 25	Full
April 5	May 28	Light	April 11	....	....	April 4	....	....
April 25	....	......	April 22	June 8	Very Lig't	April 22	June 15	Light
April 11	May 27	Very Light	April 9	May 18	Light	April 10	May 24	Light
....	....	......	....	....	....	....	....	....
....	....	......	....	....	....	....	....	....
April 12	June 10	Light	April 16	June 4	Light	April 15	June 9	Medium
April 20	....	......	April 21	....	....	April 21	June 10	Medium
April 19	....	......	....	....	....	....	....	....
....	....	......	April 6	....	....	April 6	May 26	Very Light
April 19	June 15	Very Full	April 20	June 27	Very Full	April 19	June 24	Very Full

During the past six years the dates of blooming and ripening and other related data of the above eighteen varieties have been recorded. Descriptions of most of the varieties, that have fruited, have been made. It will be seen by referring to the table, that cherries are late bloomers. The table also shows no very material difference in the time of blooming between the sour and sweet varieties.

In 1895 only six varieties, out of the eleven that bloomed, bore a crop, nothwithstanding the fact that they bloomed after danger of frost was over. The Early Richmond and Esel Rirsche produced heavy crops. In the spring of 1896 the blooming period was, in most cases, a week earlier than in 1895. No fruit ripened this season, as all was killed by the unusually late and severe frost of April 18th.

In 1897 only half of the varities that bloomed fruited, although the blooming period averaged about a week later than for the previous season. The Esel Rirsche, Early Richmond and an *unknown* sour variety were heavily loaded. On the whole there was very slight difference, in the time of blooming of the varieties, in 1898 and the previous season. Six kinds out of the number that bloomed failed to produce any fruit.

During 1899 and 1900 the blooming period of the varieties that bloomed both seasons, with the exception of the Gov. Wood and Black Tartarian, was almost the same. In 1900 there were more varities that produced fruit than for any other year during the test. It will be seen that some varieties have not bloomed every consecutive year; and every year some of the varieties that have bloomed have failed to produce fruit. In most cases, the sweet cherries are shy bloomers and the varieties of this type that have fruited, with the exception of the Esel Rirsche, are shy bearers. Every year the birds do much damage to the fruit produced by the trees in the Experiment Station orchard.

Very few varieties have given good results and the most of them are of the sour type. The Early Richmond, Ostheim and an *unknown* sour variety, and the Esel Rirsche, which is the earliest, are among the best in the test.

PLUMS

In Station Bulletin No. 27, for June 1898, the plum was discussed quite fully. Descriptions of the Native and European types which had fruited, up to that time, in the Experiment Station orchard, were published; together with the observations on the blooming period for four years (1895–1898) of 28 European, 9 Native, and 12 Japanese varieties. Soil, cultivation, irrigation, time of planting, stock, pruning, fertilization, etc., are there considered.

In the present article it is intended to give the observations made during the past two seasons and to publish the descriptions of the Japanese plums which fruited in 1900, their first fruiting season; to briefly discuss the different groups in regard to their adaptability to New Mexico conditions; and to give an account of the results of thining the fruit.

Plums are grown with more or less success throughout the territory, but the Japanese varieties, unlike the European and many of the native varieties, do not fruit successfully on account of the buds and blooms being destroyed by the late spring frosts. In many places in the territory where Japanese plums have been planted, it has been found that they are almost worthless, and these are being replaced mostly by European varieties. None of about twenty replies to a circular of inquiry about fruit, addressed to many of the principal fruit growers in different parts of the territory, give the Japanese plums as worthy of cultivation in their respective localities. On the other hand, varieties of both the other types have been reported upon very favorably. Varieties of the European group, however, predominate in all the different sections. The following table shows the time of blooming, ripening, and the comparative yield during the past two years of varieties tested in the Station orchard:

TABLE III.

European Group.	1899			1900		
	Date of blooming.	Date of ripening.	Crop.	Date of blooming.	Date of ripening.	Crop.
Bulgarian	April 13	Aug. 20	Full.	April 8	Aug. 26	Full.
Clyman	" 3	June 27	Full.	Mar. 24	July 3	Full.
Coe's Golden Drop	" 13	Aug. 20	Full.	April 8	Aug. 20	Medium.
Fellenberg	" 9	" 11	Very full	" 17	" 25	Full
French Prune	" 6	Sept. 6	Medium.	" 1	Sept. 3	Full.
German Prune	" 13	Aug. 26	Full.	" 15	" 4	Full.
Italian Prune	" 13	" 28	Full.	" 11	" 5	Full.
Imperial Gage	" 19	" 21	Very full	" 4	Aug. 12	Full.
Jefferson	" 8	" 21	Full.	" 10	" 15	Full.
Merunka	" 25	July 30	Light.	" 20	July 21	Light.
Pond's Seedling	" 18	Aug 22	Medium.	" 8	Aug. 29	Full.
Prince Englebert	" 16	" 20	Very full	" 7	" 12	Full.
Regia No. 19	" 20	July 20	Light.	....	....	....
Royale Hative	" 3	" 13	Full.	April 1	July 14	Full.
St. Catherine	" 4	Sept. 10	Full.	" 1	Sept. 8	Full.
Silver Prune	" 8	Aug. 20	Medium.	" 11	Aug. 20	Full.
Spaulding	" 13	" 25	Full.	" 6	" 15	Full.
Tragedy	" 2	July 27	Light.	Mar. 22	July 20	Full.
Yellow Eggs	" 18	Aug. 21	Full.	April 16	Aug. 24	Full.
Native Group						
Caddo Chief	Mar. 17	....	....	Mar. 13	....	....
Cumberland	" 28	Aug. 22	Full.	" 31	Aug. 20	Full.
Golden Beauty	April 6	Sept 2	Full.	April 2	Sept. 10	Full.
Mariana	Mar. 28	June 29	Very lgt.	Mar. 15	June 28	Very lgt.
Wayland	" 30	Sept. 1	Very full	" 29	Sept. 8	Full.
Wild Goose	" 28	June 24	Full.	" 29	July 2	Full.
Wolf	May 3	Aug. 16	Very lgt.	May 13	....	....

TABLE III—Continued.

Japanese Group	1899			1900		
	Date of blooming.	Date of ripening.	Crop.	Date of blooming.	Date of ripening.	Crop.
Burbank	Mar. 4	....	....	Mar. 13	July 15	Full.
Botan	" 13	....	....	" 16	" 7	Full.
Chabot	" 20	....	....	" 14	Sept. 20	Medium.
Huankume	Feb. 15	....	....	Feb. 14	May 25	Light.
Hattankio	Mar. 16	....	....	Mar. 14	June 29	Medium.
Hayo Simoni	" 28	June 28	Very lgt.	....	....	....
Kelsey	" 11	....	....	Mar. 7	Aug. 8	Very lgt.
Ogon	April 8	July 12	Very lgt.	April 8	July 14	Medium.
Prunus Pissardi	Mar. 19	....	....	Mar. 10	Aug. 20	Very lgt.
Prunus Simoni	" 20	....	....	" 14	June 30	Very lgt.
Satsuma	" 10	....	....	" 7	July 15	Light.
Shiro Simoni	" 20	....	....	" 23	" 2	Medium.

European Plums

It will readily be seen from the table how late the varieties of the European group bloomed and how well they bore during the past two seasons. The results with these plums have been very satisfactory. A record of the blooming and ripening period has been kept of these varieties during the past six years; and, with two exceptions, they have been found to be late bloomers, blooming usually after danger of killing frost is over. The Tragedy and Clyman may be called medium late bloomers. The Clyman, however, is slightly the later bloomer of the two, and seems to be a better cold resister than the Tragedy, as it usually has a better crop, ranging from a fair to a heavy one. The Clyman is a promising plum, especially so because its fruit is very early. It is the earliest of the European varieties in the test, and can be placed on the market as early as the Wild Goose. Most of the varieties in the test, in most years, tend to overbear; and in order to secure large fine fruit thinning is necessary. This is especially true of such heavy bearers as Fellenburg, French Prune, Imperial Gage, Jefferson, Prince Englebert, Royale Hative, St. Catherine, Yellow Egg and also Clyman when it produces a heavy crop.

As already said, some varieties of this group are being grown in all the fruit-growing districts in the territory. The Damson and Green Gage seem to be the leading varieties in the Las Vegas district. The Damson, Bradshaw, egg plums, and prunes have been reported to be among the leading varieties at Santa Fe. Further south on the Rio Grande and around Albuquerque the Damson and Washington are favorite varieties. On the southern Pecos Valley, at Roswell, Carlsbad and vicinity, the Damson, Pond's Seedling and German Prune are varieties most grown. In the Experiment Station orchard, of those varieties that have been tested, the Clyman, Royale Hative, Jefferson, Imperial Gage, Pond's Seedling, and Yellow Egg are among the leading plums, while the French, German and Silver are about the best among the prunes tested. See Plate II. The Damson is the most widely distributed plum in the territory.

The European plums are well adapted to this climate, and when varieties of this type are more generally known throughout New Mexico and their adaptibility better understood, there need be but few mistakes made in the selection of varieties for planting.

Native Plums

The Native plums are also well adapted to our climate. The trees are strong, vigorous growers, and most of the varieties in the test are either medium or late bloomers, and generally good bearers. The Caddo Chief and Mariana are two of the earliest bloomers; and most of the time the former bears no fruit at all, while the latter has very light crops. As a fruit tree, the Mariana is of very little value, but it makes a good stock to graft or bud other and better varieties upon, for which purpose it is used quite extensively. The fruit is small and poor in quality, and in the Experiment Station orchard it drops badly when about ripe. The best and at present the most popular variety of this type is the Wild Goose. See plate II. It has been reported from many sections in the territory as the leading native plum. In the Experiment Station orchard the Wolf is the latest blooming variety (see Table III and Station Bulletin No. 27) and is a heavy bloomer. Notwithstanding this fact it has failed to produce fruit, except in 1899, when only a few plums ripened on the trees for the first time in five years.

Many native plums do not fertilize themselves. In this connection Professor L. H. Bailey[1] says, "The chief difficulty in the growing of native plums is the fact that some varieties do not fertilize themselves. The peculiarity appears to be due not to any imperfection in the flowers but to the comparative impotency of pollen upon flowers of the same variety. The impotency of pollen appears to be characteristic of certain varieties, as for example, Wild Goose, Miner, Wazata, Minnetanka, Itaska." Professor F. A. Waugh[2] says, "For

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1. Cornell University Agricultural Station No. 38. (1892)
2. Vermont Experiment Station Report, Page 88. (1897)

all practical purposes all classes and varieties of native plums may be regarded as absolutely self-sterile." In the Vermont Experiment Station Bulletin No. 53, Professor Waugh gives the Rollingstone, De Soto, Pottawattomie, Wolf and others as not fertilizing themselves. In experiments conducted by him along this line the Wolf gave nine fruits from about two hundred blossoms that were covered; this shows a case of self-sterility. The failure in the Wolf not fruiting in the Experiment Station orchard seems to be on account of the blooms not being fertilized; as when it is in bloom all of the other varieties in the orchard are through blooming, and hence no pollen from the other varieties is available for cross-pollination. Generally speaking these plums differ materially from the European varieties, in that they are not so large and usually less firm, thus rendering them less desirable as shippers.

Japanese Plums

The Japanese plums have had a "run" in New Mexico. People have planted many of them only to find out, in time, that they were worthless. Such experiences are always discouraging and costly. We find varieties among the Japanese (see Table III) that are earlier ripening than either the Wild Goose or the Clyman—an excellent feature if they were only sure bearers. It is to be regretted that as a rule the Japanese plums, which have been an important addition to the orchard fruits in many other states, do not fruit successfully in this climate. Notwithstanding the fact that the Japanese plum is adapted to a wider range of territory than either the European or native plums, and while in New Mexico the trees thrive and bloom profusely, yet this type of plum does not fruit nearly so succesefully as the European varieties.

In the Experiment Station orchard 12 varieties have been tested, and since 1895 observations on the blooming and ripening periods have been taken. All are good, heavy, and, with one exception early bloomers. The Ogon is the only variety in the list that approached being a late bloomer, and it usually bears a crop. The fruit, which is round, medium and yellow, drops badly just as soon as it begins to ripen. The Huankume, Kelsey and Satsuma are exceedingly early bloomers, while the Botans, Burbank and Hattankio are slightly later. Occasionally a few blooms escape the frosts; but with the exception of the Ogon, there has never been a crop on the Japanese varieties in the orchard, except last year. The spring of 1900 was unusually favorable in the absence of the late severe frosts, and as a result of this favorable spring the Japs bore a crop. Occasionally the spring is so mild that the main crop of blooms is not destroyed by the frost, but such springs are the exception and not the rule. Of all the Japanese varieties tested not one can be recommended for extensive planting. If, however, people are satisfied with one crop in about every five or six years, a few trees of the Burbank, Botan and Kelsey could be planted.

Description of Japanese Plum Which Fruited in 1900

Botan—Size large, roundish, ovate, with pointed apex; cavity deep, and narrow; distinct suture; color reddish purple on a yellowish ground; bloom light blue, heavy; smooth surface with small brownish dots; stem short and slender; flesh dark green, very sweet, juicy and delicious, clings to the small flat stone; quality excellent; tree good grower, vase shaped, early bloomer, first time it has produced a crop in six years,

Burbank—Size large, ovate to globular, with a full apex; cavity deep round, slanting; suture indistinct; stem slender to moderately long; surface smooth, with large light greenish yellow dots, covered with a light lavender bloom; color greenish yellow splashed with red; flesh deep yellow, juicy, sweet, rich, clings to small flat pit; on the whole is very attractive and good; tree medium but vigorous, somewhat spreading with occasional upright shoots; this is the first year in six there has been a crop on the trees.

Chabot—Size medium, roundish oval to oblate with apex very slightly pointed; cavity deep, abrupt, narrow; suture shallow; stem slender and moderately long; smooth surface with numerous small yellowish dots, covered with a copious bluish bloom; color yellowish overlaid with crimson; flesh orange, moderately juicy, slightly subacid, clings to the small oval pit; quality fair; tree weak grower.

Huankume—Size very small, somewhat roundish and downy; yellowish red; slightly acid, tastes like an apricot, which it resembles in some respects; cling stone; tree small, not a vigorous grower, the earliest bloomer of the plums in the Station orchard (see Table III.)

Hattankio—Size large, ovate, ending in a long sharp apex; cavity narrow and deep; suture indistinct; stem short and slender; a copious light bloom; color greenish yellow; flesh lemom yellow, sweet, juicy, good, clings to the flattish oval, perforated pit; tree a vigorous grower, somewhat spreading, tends to break when the limbs are bent down.

Kelsey--Size large, heart-shaped; cavity narrow, deep; suture deep; stem short and stout; smooth surface with many small light dots, covered with a copious light blue bloom; color greenish yellow to purple; flesh green yellow, juicy, very good; tree good grower upright and spreading; blooms very early.

Prunus Pissardi—Size medium, almost round, with a slightly compressed apex; cavity narrow and shallow; suture indistinct; smooth surface with dark dots and covered with bluish blooms; stem long and slender; color reddish purple; flesh red to purple, juicy, clings to the pit; fair in quality; fruit is red from the time it sets, taking a purple tinge as it ripens, tree vigorous, medium, with quite a round head, foliage reddish, especially newer growth; makes a nice ornamental tree; this is the first year in six that it has fruited; bloomed too early.

Satsuma—Size medium to large, almost round, terminating in a slightly pointed apex; cavity deep, narrow, abrupt; suture almost indistinct; stem slender, moderately long, surface smooth and dots very conspicuous; covered with a thin bluish bloom; color greenish yellow, splashed with red; flesh blood red, slightly acid and juicy, clings somewhat to the small pit; tree large, vigorous, vase shaped, very early bloomer.

Prunus Simoni—Size large, flattened with deep large cavity and depressed apex; suture deep; stem short and stout; smooth surface with small greenish dots, covered with a light bloom; color brick red; flesh yellow, firm, juicy, good, slightly adhering to the small roundish flat, perforated pit; the fruit resembles a small flat apple; tree small. This year (1900) was the first year it bore; three trees produced ten pounds.

Shiro Simoni—Size medium to large, flattish ovate, having one side slightly larger, with a narrow and deep cavity and a comparatively long obtuse apex; distinct suture; stem short and slender; color scarlet to purple; copious blue bloom; flesh deep yellow, juicy, tough, slightly acid, clings to the small flat pit; fruit is very attractive but poor in quality; tree vase shaped, vigorous.

Gold Burbank—Size medium almost round, with deep narrow cavity and slightly compressed apex; suture indistinct; stem short and slender; smooth surface with numerous light dots, covered with a whiteish bloom; color golden, with an almost red cheek, flesh golden, juicy, slightly sub-acid; clings to the small pit. Tree vigorous, spreading, with a round head.

THINNING PLUMS

The thinning of fruit for the purpose of causing that which remains on the tree to grow larger is a well known practice, but followed less than it should be. Thinning is not only beneficial to the remaining fruit, but it also tends to save the energy and vitality of the tree, and tends to equalize the yield from year to year. The operation of thinning fruit is somewhat expensive and laborious, but it is an operation that pays quite well in an orchard. While thinning is not so generally practiced with plums as with peaches, in some cases the results may be equally as good. During the season of 1900 some thinning experiments with plums were carried out in the Experiment Station orchard, and the results are herewith given. Three trees of each of the following varieties were taken : Clyman, Wild Goose, Tragedy, Yellow Egg, and French Prune. The French Prune was discarded at the end of the season, because all the plums were about the same size

Two trees were thinned, one left unthinned ; and two methods were tried.

First—The fruit was thinned to approximately six inches apart, on one tree of each of the five varieties. Second—The fruit was thinned to approximately three inches apart on one tree of each of the five varieties. A check tree of each variety was left unthinned.

The fruit, when ripe, was sorted out into different grades, Nos. 1, 2, and 3, as near as could be done with the eye. Each lot was counted and weighed. The fruit of each variety was graded irrespective of the fruit of the other varieties *i. e.* no common standard of size was taken. To have a common standard of size was almost impossible ; as the varieties in the experiment varied so much in size and ripened at such different times, that what was graded as first-class plums of one variety and at one time would not answer for all varieties. The first-class plums were sold in different parts of the territory as first-class fruit. The second-class plums were not shipped out, though some of them were sold at a lower price in the neighborhood. To see if the second-class fruit could be shipped out, a few baskets were sent to Mr. F. C. Barker, secretary of the Mesilla Valley Fruit Shipping Association, through whom all our fruit was sold. Mr. Barker returned the second-class plums with the statement that they were unfit to ship out. Thus it was commercially shown that the second-class fruit was not fit for the market.

The following table shows the per cents of the different classes of fruit produced by the thinned and unthinned trees.

TABLE IV

NAME	Distance Thinned in Inches	Per Cent of First Class Fruit	Per Cent of of Second-Class Fruit	Per Cent of Third-Class Fruit
Wild Goose	6	75.7	24.2	....
	3	70.1	28.8	....
	None	67.4	32.5	....
Clyman	6	93.4	6.5	....
	3	85.9	14.	....
	None	53.7	46.2	....
Tragedy	6	86.4	13.5	....
	3	96.9	3.	....
	None	53.7	46.2	....
Yellow Egg	6	81.1	15.9	2.8
	3	57.5	30.6	11.8
	None	27.5	53.	19.3

It will be seen from the table that, in every case, the per cent of first-class fruit produced by the thinned trees exceeds the per cent of first-class fruit produced by the unthinned tree of such variety. The table also shows that, with the exception of one case, the per cent of first-class fruit produced by the trees thinned to six inches exceeds the per cent of first-class fruit from the trees thinned to three inches. In the case of the Tragedy tree thinned to three inches, nearly all the fruit was first class; and the per cent of large fruit exceeds that of the tree thinned to six inches by about ten per cent. With the Clyman trees there is a decided difference in the per cents on the thinned and unthinned trees. The crop of the unthinned tree was nearly all second-class fruit, there being only two per cent of large plums. Considerably over half of the crop from the unthinned trees of the Clyman and Yellow Egg was small fruit, while slightly less than half of the crop produced by the unthinned Tragedy tree was small fruit.

While this work is somewhat preliminary in character, the results are encouraging, and show that by thinning the per cent of salable fruit is considerably increased.

QUINCES

Only four varieties of quince have been grown in the Experiment Station orchard, but these have done quite well. The trees seem to prefer a light soil, as is shown by comparison with those trees growing in adobe soil. The latter, as has already been said, is seemingly almost impervious to water, and only by holding the water on it for some time does it become soaked to a considerable depth.

The quince is well adapted to this region. In past years the quince was somewhat of a favorite fruit among the Mexican farmers of this locality. Many seedling trees have been grown for years by the Mexican farmers, and these seedlings as a rule bear good crops of fruit.

Champion, Missouri Mammoth, Orange and Japan are the four varities growing in the Station orchard. In 1895 they bloomed between April 8th and 15th. These fruited some for the first time. During the spring of 1896 all four varieties were in bloom by April 9th, but the unusually late and severe frost of April 18th killed all the fruit that had set. In 1897 all four were in bloom about April 7th. The Missouri Mammoth, Champion and Orange had good crops, while the Japan bore only a few fruits. In 1898 the quinces, together with all of the other fruit in the orchard that was not ripe by July 15th, were destroyed for the purpose of ascertaining the effect on the coddling moth the following season. Good crops were produced by all, except the Japan, in 1899 and 1900.

FIGS

It has always been thought by people who did not know the climatic conditions of the territory, that citrus and semi-tropical fruits grew and fruited successfully under natural conditions in New Mexico, but such is not the case. It is true that some of these fruits grow, but the climate is too severe for their successful fruiting. In this vicinity a few date palms have been grown, but they have never fruited, because the growth is killed back to the ground every winter. In the same way, unless protected, the fig is winter-killed to the ground every year. Fig trees grown in yards where they are protected either by the house or high corral walls, or when they are wrapped around with sacking or "heeled in," seldom get winter-killed severely. A few specimen trees can be found bearing in some of the home yards of this locality.

At the station the six varieties, Adriatic, Col. Black, Early Violet, Black Bounjasotte, Peagustra and White Ginoo, that were set out ten years ago, make a good growth from the ground every summer, only to be killed back in the winter. In the spring numerous sprouts come up from the crown at the surface, and the tree looks more like a big bush than a tree. The sprouts make a good growth of six or more feet during the summer, and some of the larger sprouts sometimes produce fruit, but it usually sets so late in the reason that it does not ripen. The six varities under test have never ripened any fruit. Generally speaking the fig is too tender for this climate, and when grown, unless artificially protected, the new growth may be expected to be killed back during the winter.

PRUNING BACK THE PEACH

Many of the peach trees in the orchard, through constant thinning out of the lower limbs and not "heading in" the "leaders," had become bare of fruiting wood at the base, and the trees had grown so tall that it made it quite difficult to pick the fruit. By this thinning out of the lower limbs the center of the tree becomes thinly leafed, and thus not only the trunk and center of the tree, but the larger limbs as well are exposed to the rays of the sun: and in the course of time this results in some sunscald, which is believed to have something to do in shortening the life of the peach tree in this region.

During the spring of 1899, under the direction of Professor Charles A. Keffer, who was then in charge of the department, a great many peach trees were severely pruned back. The objects in view in this experiment were to renew the tree by inducing new and vigorous growth; to bring the bearing wood nearer the ground, and at the same time to form a dense crown which would protect the larger limbs, center and trunk of the tree.

In this experiment three methods of pruning were used.

In the first, the trees were pruned to stubs, leaving them four to five feet high. The branches cut were six years old, as shown by the rings on the stubs. A sprout of the previous year's growth was left just below the cut. This one year old wood was left to induce growth in the branches. The second method was more moderate; only branches of three to four years old were taken off, always with the view of leaving the tree as shapely as possible. In the third method only two year old wood was removed from the large limbs. In this case there was more bearing wood left on the trees, though further from the ground than on the trees more severely pruned.

In almost every case the most severely pruned trees produced a growth of shoots so numerous and vigorous that by May 8th many were over a foot long, when they were thinned, leaving them from two to two and a half feet from the ground, up to the end of the limbs. By May 15th the sprouts left were branching vigorously. Several times during the summer it became necessary to go over these trees and cut out the shoots which kept coming out all over the limbs. On the other hand, the new growth on the less severely pruned trees was confined more closely to the immediate neighborhood of the wound on the limb. and, in most cases, only two to four new shoots grew from each limb.

During the summer there was very little fruit on the severely pruned trees. This was naturally to be expected, since, by the very nature of the operation, very little bearing wood of the previous year's growth was left on them. On the other hand, the less severely pruned trees had more bearing wood on them, and consequently they had a better crop. This severe method of pruning seems to be objectionable, inasmuch as a crop of peaches is practically destroyed by the operation. This, however, only happens once or twice during the lifetime of a peach tree, and since the peach bears its fruit on the previous year's wood, the shortage in fruit due to the pruning would only be for the current year. To obviate this difficulty a season could be chosen in which the crop has been destroyed by the frosts ; or in the case of the early varieties, like the Alexander, Waterloo and Hynes' Surprise, which are not very likely to be destroyed by the spring frosts, the pruning need not be quite so severe.

The new shoots on all the trees made a vigorous growth during the season, and on the more closely pruned trees the bearing wood was considerably nearer the ground. The following season, 1900, there were plenty of fruit buds on the new wood and the fruit was larger and in every respect nicer on the pruned trees than on the non-pruned trees of the same variety. No material difference was observed on the fruit of the differently pruned trees, except that in some cases the less severely pruned trees had more fruit, seemingly due to the larger amount of bearing wood. By the end of the second season most of the trees had made a low, dense and vigorous growth, see, Plate III. There were a few trees that died, but these would have died anyway, owing to their weaker condition.

This experiment shows that the peach tree will stand very severe pruning, and where the tree has been allowed to grow without being "headed in" this method of pruning may prove very beneficial; and comparatively old trees can be renewed. Such pruning to produce the best results should not be put off until the tree is on the rapid decline.

SUMMARY

1. The apricot is of no commercial importance in New Mexico, because it blooms too early to escape the late spring frosts, though the trees are perfectly adapted to the climate.
2. The sour cherries do better in the territory than the sweet varieties. In the Station orchard, Esel Rirsche, a sweet variety, Early Richmond, Ostheim and an unknown sour cherry have given the best results.
3. European plums are very successful in this climate. Most of the varieties tested in the Experiment Station orchard are late bloomers and sure bearers. The Tragedy and Clyman are medium late bloomers.
4. The Native plums are also well adapted to this climate,

though on the whole they are slightly earlier bloomers than the European varieties.

5. The Japanese plums are very early bloomers, and therefore, owing to the prevalence of the late spring frosts, they are practically worthless.

6. Thinning plums increases materially the per cent of salable fruit.

7. The quince does well in this climate. The trees do best in a light soil.

8. Figs are too tender for this climate, and unless protected the new growth is killed back to the ground during the winter.

9. Peach trees will stand very severe pruning, and comparatively old trees may be renewed by this method.

ACKNOWLEDGMENTS

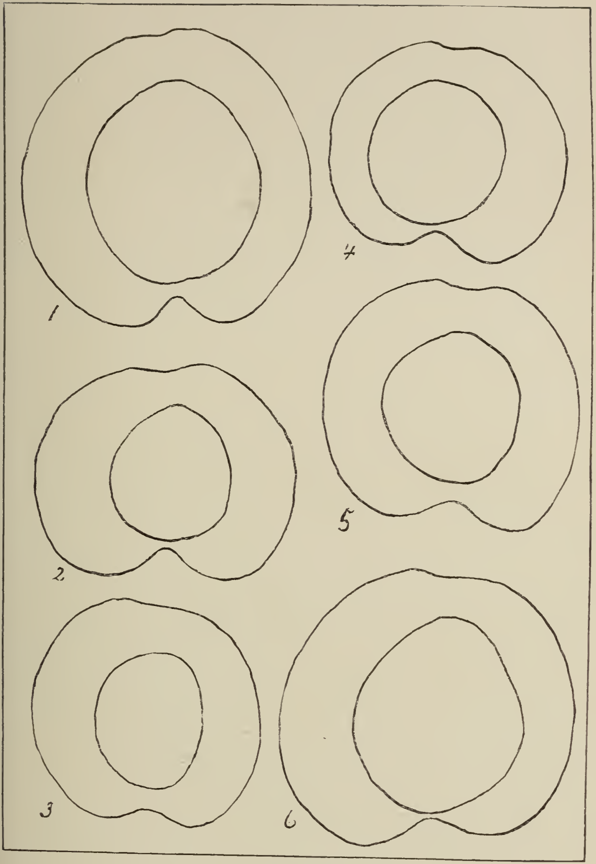
The writer is indebted to the following persons for valuable information, regarding the adaptability to their respective districts of the apricot, cherry and plum:

Hon. L. Bradford Prince. Mr. Arthur Boyle and Mr. Grant Rivenburg, Santa Fe, Santa Fe county; Mr. John Thornhill, Las Vegas, San Miguel county; Mr. A. M. Whitcomb, Albuquerque, Bernalillo county; Mr. Parker Earle, Roswell, Chaves county; Mr. F. G. Tracy and Mrs. Mary B. Sharp, Carlsbad, Eddy county; Mr. F. H. Niemeyer, Florence, Eddy county, and Dr. C. M. Grover, Frisco, Socorro county.

Some of the data reported in this bulletin were recorded by Mr. Humboldt Casad, formerly of this department, to whom credit should be given for the same. Thanks are due to Miss C. M. King, Iowa Agricultual College, Ames, Iowa, for the line drawings of the apricots and plums.

Professor L. H. Baily's Cyclopedia of American Horticulture has been freely consulted; also some of his bulletins on plums, as well as Professor F. A. Waugh's works on the Native plums, have been referred to.

PLATE I

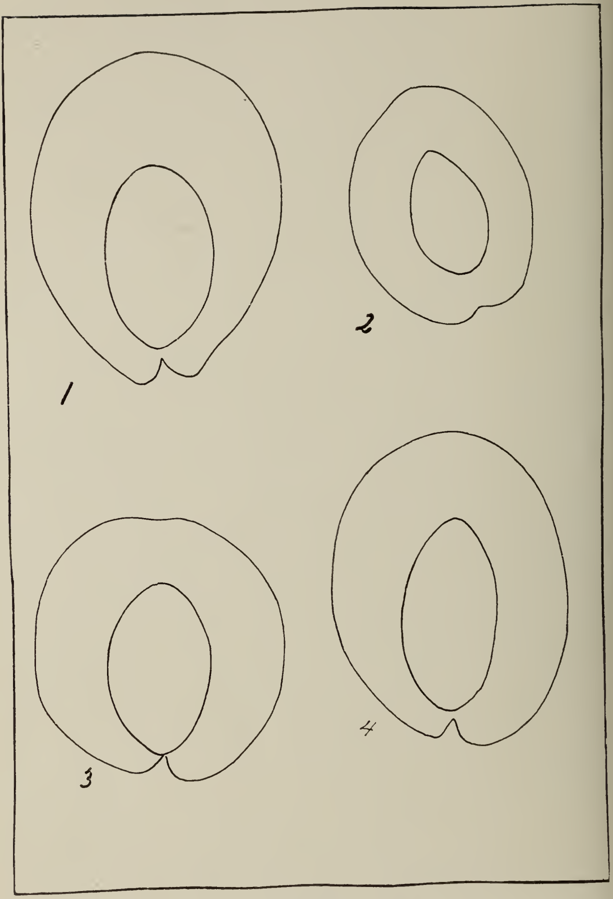


APRICOTS

1 St. Ambroise
2 New Castle
3 Bungouma
4 Large Early
5 Moorpark
6 Luizet

Natural Size

PLATE II



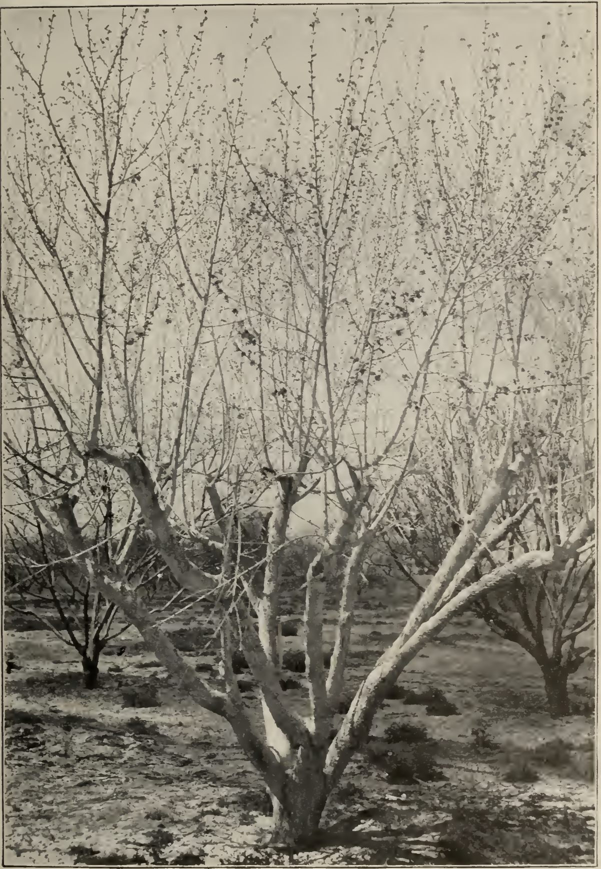
PLUMS

1 Silver Prune
3 Pond's Seedling

2 Wild Goose
4 Yellow Egg

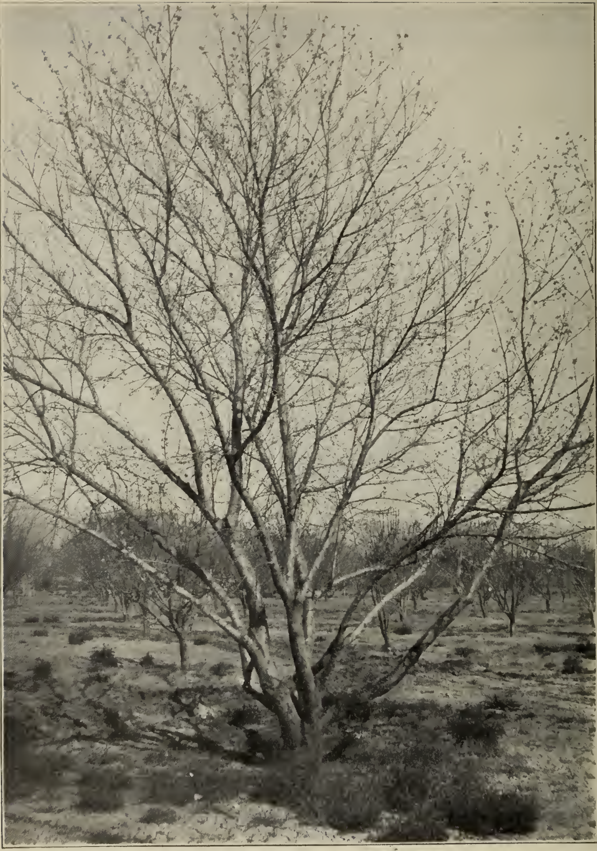
Natural Size

PLATE III



Mamie Ross Peach Tree severely pruned, showing two seasons' growth after pruning

PLATE IV



Mamie Ross Peach Tree, not pruned.

BULLETIN NO. 40

NOVEMBER, 1901

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

"Sunset" and "Maman Cochet" Roses

A SOUTHERN NEW MEXICO FLOWER GARDEN

BY

FRANCIS E. LESTER

SANTA FE, N. M.:
NEW MEXICAN PRINTING COMPANY.
1902.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others as far as the editions printed will allow.

INTRODUCTION

The question of beautifying the surroundings of New Mexico homes by lawns, flowers and shrubbery is no longer a doubtful one. The popular notion, held not many years since, was adverse to believing in the now known possibilities of floriculture within the borders of the territory. This very erroneous and misleading idea, under the salutary influence of progressive and persevering individuals, is, we are glad to note, rapidly giving way to one of general inquiry into these possibilities.

We believe that this bulletin by Mr. Francis E. Lester, entitled "A Southern New Mexico Flower Garden," which is presented in a popular style, giving detailed notes, will be found of great value to those seeking information as to how to grow flowers and what varieties to select, in southern New Mexico.

Progressive teachers in our public schools who are endeavoring to give instruction in "Nature Study," which has become so popular and has made such rapid progress in some states, will find much within these pages that will interest and assist them in their work.

J. J. VERNON, Agriculturist.
FABIAN GARCIA, Horticulturist.

November 15, 1901.

A SOUTHERN NEW MEXICO FLOWER GARDEN*

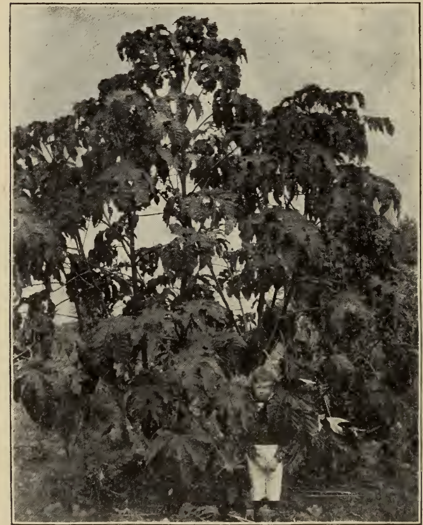
"God Almighty first planted a garden."—Bacon.

* * *

"Like the love of music, books and pictures, the love of gardens comes with culture and leisure and with the ripening of the home life. The love of gardens, as of every other beautiful and refining thing, must increase to the end of time. More and more must the sympathies enlarge. There must be more points of contact with the world. Life ever becomes richer. Gardening is more than the growing of plants: it is the expression of desire." L. H. Bailey.

* * *

The earlier settlers in New Mexico found little time to give to the cultivation of flowers. With a population made up mostly of those who were striving to earn a fortune or a livelihood, not much attention was given to this finer branch of horticulture. But the times and the character of the population in our territory have changed, and today there are ten persons where not many years since there was but one, who are making some attempt to have a flower garden.



RICINUS ZANZIBARENSIS (The Mammoth Castor Bean) Photographed in September, 1901, four and one half months after sowing the seed.

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*The illustrations in this bulletin are from photographs taken by the author of results secured in his own garden.

The author desires to acknowledge the value of many helpful suggestions received in the preparation of this bulletin from Mr. F. C. Barker, of Las Cruces, N. M., who has had an extensive and valuable experience with flowers in southern New Mexico.

But many an enthusiastic gardener has found to his disappointment and cost that conditions in New Mexico are very different from those surrounding the flower gardens of most other regions. The seasons and the climate are different, and the methods of sowing and planting and caring for flowers that are followed in other states are mostly unsuccessful here. A host of plants and flowers familiar to eastern gardens will not thrive in southern New Mexico without extraordinary care, if at all, while there are many unknown to outdoor culture in a more rigorous climate that are at home with us and produce most satisfactory results.

A flower garden makes the home more home-like. Every southern New Mexico home should have its flower garden—large or small. Even the lonely adobe house on the plain may be adorned by the adaptation of such native plants, requiring no irrigation after once being started, as the tamarix or the wild flowering willow. And for all who live where irrigation is practiced, roses and poppies and verbenas and a dozen other flowers should and may be far commoner than they are. There should be more home-grown flowers in southern New Mexico homes. No bought flowers are so sweet as flowers cut from your own garden, whose growth has been tended by your own hands.

It is to aid the amateur gardener,—for he it is that often loves flowers the most,—that this bulletin is published. The author lays no claim in this publication to exhaustive experimentation nor to absolutely reliable data. It is merely desired to set forth herein, in a plain and practical way, experiences and observations covering a residence of some ten years in southern New Mexico, in the hope that they will aid others who love flowers and who desire to grow them as an aid to the beautifying of a home. If, too, this little work serves to stimulate an interest in the creation of flower gardens and to dispel the all-too-common idea that "flowers will not grow in New Mexico," the author's work will have been well repaid.

Climatic Conditions

Chief among the considerations to be borne in mind in the creation of a flower garden in southern New Mexico, is the climate. The dry atmosphere, the scarcity of rain, and the hot sun during the summer months, make conditions which, whilst fatal to success with many plants, are suited to others. The enthusiast who starts out with such moisture-loving flowers as fuchsias and begonias in his garden is doomed to disappointment. On the other hand, the list of popular and beautiful flowers that will succeed with only ordinary care is so large that there is no excuse for anyone who owns a few square feet of land and can make use of irrigating facilities not having flowers for nine months, at least, out of the twelve.

Our summer heat, combined with the extreme dryness of the air, create unfavorable conditions for many flowers. Especially do these conditions affect the growing of flowers from seed, since the baking of the soil after irrigation often prevents the growth of the tender sprouts from the smaller seeds. It is frequently advisable to provide for some flowers artificial shade during the hottest part of the summer, which may be done by means of a canvass screen, or other methods. The high spring winds, too, are injurious to all flowering plants, and windbreaks should be provided if the location of the garden is at all exposed. These high winds, coming, as they do, in the months of March and the early part of April, are often succeeded by frosty nights which find plants of all kinds—robbed of much of their moisture by the dry winds—in no condition to resist the cold. Irrigation at these times is always helpful, so that vegetation may be supplied with ample moisture. The winters of southern New Mexico, excepting in the mountain ranges, are not severe enough to require special protection for many plants that would succumb in the middle and eastern states, and tea roses may be safely carried through our winters without extraordinary protection, provided the soil is not allowed to dry out.

The Soil and its Preparation

The adaptability and preparation of the soil is one of the principal requirements for success with a flower garden. A sandy loam is preferable for this purpose to a heavy adobe soil. Much can and should, in any case, be done to improve the condition of the soil. For this purpose. ordinary barnyard manure, preferably from an old cow corral,—should be used liberally, not so much, perhaps, for its fertilizing properties as to improve the texture of the soil and to increase the humus. By the repeated application of manure containing a large proportion of straw or chaff, the tendency in a soil to bake will be largely overcome. Should the soil be too sandy the manure will still be an improvement. It may be applied during the fall, winter or spring. If in the fall or winter, spade it well into the ground; if in the spring after the garden has been planted, it will serve as a useful mulch for the hot weather to prevent the baking of the soil. In any case, it will pay the amateur well to prepare the soil carefully before planting his flowers or sowing the seed. This almost universal tendency of our soils to bake in the sun after each irrigation is injurious to plant life. "Cultivate after each irrigation" as soon as the soil is dry enough to work, is the great remedy for this trouble. Where irrigating water containing much sediment is used, this precaution must be followed closely; and occasionally river water may be so thickly charged with sediment as to make it unwise to irrigate the smaller and more tender plants at all.

How to Start the Plants

The beginner who looks for great results by following the florists' directions given for the spring sowing of flower seeds, as practiced in other climates, will surely be disappointed. Not all of the small grained seeds will succeed under ordinary conditions here, and of these many must be sown in the fall. The rapid drying out of the soil in the spring sun and with the spring winds, prevents the germination of the seeds which are so small that they must be sown in shallow soil. Many methods have been tried to overcome this drying out of the soil. An ordinary tin can, perforated around the sides and sunk in the center of a seed bed, is sometimes used, water being poured into the can daily or oftener. Another plan is to cover the seed bed with sacking, chaff or thick brush, removing it as soon as the seed has sprouted above the ground; and still another is to cover the seed with boxes or heavy shade until the seedlings are well started. All these methods, however, are only partially successful, and when the temporary shade or protection is removed, a few hours of our spring winds or a couple of days' hot sun may kill the young seedlings. Generally speaking, the best results from seed grown plants will come from the larger seeds, those that have strength enough to force themselves through a hard surface, such as sweet peas, castor beans, morning glory, zinnias, hollyhock, etc. If, however, small grained seeds are sown, sow them deeper than the printed directions, covering them first with a light layer of fine soil and then with a layer of finely pulverized manure. But best of all, purchase healthy plants, setting them out at the right season of the year, usually in the

Hybrid perpetual and hybrid tea roses in the open garden, October, 1901. These roses are California stock, set out in March, 1901; two year old plants.

spring, and protecting them by means of tin cans (ventilated with holes) or flower pots or boxes for a few days, until they have become well established. The same amount of money expended on the smaller seeds and on plants will produce, with the same care, more and better results from the plants than from the seeds. Generally speaking, avoid sowing or planting new varieties of plants or the advertised "novelties" of florists, unless you are prepared to give them special care. Old established varieties and strains do the best, and single varieties of flowers usually are better for the amateur's garden than double.

If a cold frame is available,—and one can be readily and cheaply constructed by any handy person,—many of the best flowers may be easily started from the seed during the winter months, and by spring the young plants will be large enough to transplant to the open bed. The results obtained in this way in the Experiment Station flower garden have been especially successful. A cold frame may be covered either with the ordinary glass sashes or with sashes covered with a strong grade of muslin.

Sowing Seed in the Fall

Many seeds that fail to germinate if sown in the spring produce excellent results if sown in the fall. Indeed, the fall sowing of seeds should be practiced much more extensively than it is. This is shown by the number of plants that come up from self-sown seed each year, when once the plants have become established. The bachelor's button, poppy and larkspur are striking examples of this. The author for several years miserably failed to get any success with poppies, sowing the seed, according to the directions printed in florists' catalogues, in the spring, until one year when a few carefully tended but sickly looking plants grew, flowered and went to seed. The next spring, a multitude of seedling plants came up from the self-sown seed of the weakling plants, and produced a little sea of gorgeous color. Since that experience, fall sown poppy seed has always borne good results, and poppies of all kinds and colors bring forth each year their beautiful showing of blossoms. Among others, the following seeds will give good results from sowing in the fall: Alyssum, carnation—the commoner varieties, centaurea (bachelor's button), dianthus (pink), escholitza. Iceland poppy, larkspur, mignonette, phlox drummondi, poppy, verbena, zinnia. A little protection of brush, dead leaves or rough mulch will help most of the above during the colder winter weather. October is the best month for the fall sowing of flower seeds. Whenever possible, procure native grown seed which in most, or all, cases does better than that imported from a different climate.

Flowers seem to love companionship in their growth. Self-sown seed appears to grow better than that sown artificially. The amateur starting his garden on bare ground, as the writer did a number of years ago, must coax his flowers and seeds until they become well established and feel the environment of companionship that comes from other plants. A few solitary plants will find it a hard struggle for existence; but when once flowers and vines and shrubs find that they have companions they seem to take courage, join hands in their effort to live, and finally run wild and take possession of the garden in a manner to delight the heart of the gardener.

The Adaptation of Native Plants

Very satisfactory results can be obtained in a flower garden by adapting the native flowers and shrubs and trees,—transplanting them from their native haunts to the garden. We too frequently overlook the beauties and possibilities of our wild flowers. Many a wild flower, transported to another region, becomes a "rare and beautiful" introduction and is made the subject of an elaborate description and a fancy price by some enterprising florist. Our mesas abound with the most beautiful yellow "daisies" in various species, while the mountain cañons give us such flowers as the yellow columbine. Not long since, the Experiment Station Botanist, Prof. E. O. Wooton, described a rose new to science which grows wild in the Organ and Sacramento mountains of southern New Mexico, and which is one of the finest wild roses known. This may be transplanted, and under cultivation will doubtless improve. A striking example of the improvement of a wild plant under cultivation is the flowering willow, which is found in the dry arroyos near our mountain ranges. This is a valuable shrub for the garden, bearing more profusely and much finer blossoms than in its wild state. The native cacti, too, make a beautiful showing if transplanted to the home garden, and there are many other native flowers equally worthy of notice. For fall sowing, the native asters may be used, being free bloom-

The native flowering Willow, under cultivation. An example of the success attending the adaptation of native plants and shrubs.

ers and well adapted for mixed bouquets. *Aster commutatus* and *A. hesperius* are two of the best of these. *Machaeranthera linearis* is another native flower worty of cultivation. The study of the native wild flowers is a great aid to success with a flower garden, since it is always probable that the cultivated varieties of our wild flowers will succeed.

Trees

Closely allied with the creation of a flower garden, and as necessary adjuncts thereto, are trees and hedges. This bulletin cannot pretend to take up the large and important question of shade trees,—a question upon which much more information is generally needed. The planting of shade trees, of varieties that will grow and do well in our climate, should be done much more extensively, both in town and country, than is at present the custom. With the average person, the choice of shade trees is confined to the ordinary cotton wood and the locust. These, however, are but two of many that experience has shown will succeed. The mulberry, apricot, walnut and pecan make excellent shade trees and are valuable for their fruit; whilst the mountain ash,—a native tree,—the Japanese umbrella, the elm, the wild olive, and several others do well. Almost the reverse of what is true in the eastern states, the maple is a slow and uncertain grower with us, while the elm is a comparatively rapid growing and thrifty tree.

Where the immediate effect of trees is desired, the larger castor bean may be grown from seed sown in April. This large variety, *(Ricinus Zanzibarensis)*, although only an annual, will produce plants that are veritable trees, 12 to 18 feet in height, in one season, with stems four inches and over in thickness, forming a dense shade and producing a pretty effect. (See page 4.)

Hedges and Windbreaks

A well trimmed hedge is, unfortunately, a rare thing in southern New Mexico. Yet nothing is more in place in a garden, both for ornamental and useful purposes. As a windbreak, a hedge is almost a necessity. For this purpose many plants are well suited and do well. The tamarix (tamarisk, African juniper), commonly known as the "salt cedar," makes a very rapid growth, will grow without irrigation when once it is well started, and makes a pretty hedge. It is easily started in the spring from cuttings. The Osage orange is better suited for the purpose of a defensive hedge and grows rapidly. Both the above, however, are gross feeders and draw heavily from the soil for some distance away, so that it is useless to attempt to grow much near them. The California privet grows well, and although a much slower grower than either of the former, will give better permanent results, is more suited to garden purposes, and in our climate is almost evergreen. *Pyrus Japonica*—the Japan quince—is also worthy of notice, its glossy foliage, which lasts for most of the year, and its gorgeous blossoms in the spring, making it particularly attractive. The honey locust, although a slow growing hedge plant, gives satisfactory results and is useful where a defensive hedge is required; and the common Bird of Paradise *(Caesalpinia Gilliesii)* can be grown as a hedge plant with pretty effect. A hedge of roses is also possible and easy to create, using the wild and common roses. An evergreen hedge may be made with the arbor vitæ, and although this is a slow grower, hardly anything will make a better permanent windbreak for a garden. The shelter of a windbreak is mostly needed in the spring time, before most trees or hedge plants are in leaf; hence, an evergreen windbreak is to be much preferred. All hedges should, of course, be kept well trimmed from the time they are started.

Lawns

Every home garden of sufficient size should have its lawn, particularly in a country where the eye can so seldom rest itself on a stretch of green grass. Nor is a lawn so difficult a thing to secure if the right methods are followed. With most amateurs little success will attend the plan practiced in eastern states and urged in gardening books—that of sowing the seed. To make a lawn, first prepare your soil thoroughly, leveling it and having it well pulverized. Secure the necessary amount of Bermuda grass sod to plant the required space, cutting the sod up into small pieces the size of an average potato and planting these pieces a foot or more apart. Spring time is to be preferred for planting,—from February to April. Irrigate after planting and your sod will start growing at once and within a year, with proper attention, it will have covered the ground and formed a thick mat. The grass must, of course, be kept trimmed by a lawn mower as it grows, and care should be taken not to irrigate with too muddy water, which may cover the grass so thickly with sediment as to temporarily kill off the surface growth. There are objections to Bermuda as a lawn grass. It turns brown during frosty weather and it spreads so rapidly as to take possession of the surrounding land, ultimately killing out everything else thereon. For the latter reason, it is advisable to limit the boundaries of your lawn by walks, over which the grass cannot trespass. Whatever you do, do not plant Bermuda grass unless you have decided to have it on the selected plot permanently, for it is practically impossible to kill it out by ordinary means. The finer lawn grasses may be planted, and even grown from seed if shaded and carefully tended; but for the ordinary person, with a limited amount of time to spend on a garden and no disposition to sit up o' nights watching it,—together with a possibly uncertain water supply,—the Kentucky blue grass and the lawn mixtures will not give as sure and satisfactory results as the Bermuda. There are, however, possibilities with some native grasses and in the acclimatization of others, for lawn purposes, worthy of careful investigation.

Vines

In so sunny a country as ours, every house should have its "vine-clad porch." For covering porches, trellises or unsightly objects in a garden, most of the ordinary vines are well adapted and will grow luxuriantly. The wild clematis

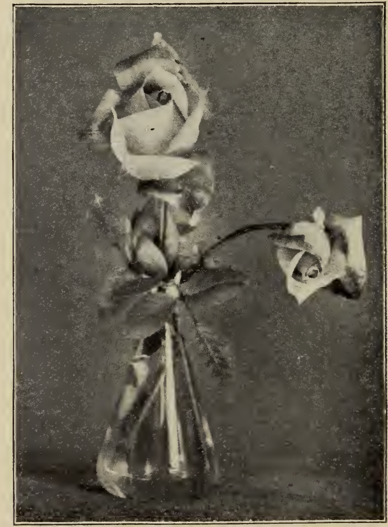
(*Clematis ligusticifolia*), will take complete possession wherever it is planted even, when once well started, to the exclusion of other vines, but it is a somewhat untidy vine. The *Clematis paniculata*, to be had from florists, is a much more satisfactory vine, and with a southern exposure will retain its bright green foliage most of the winter, but it is not so rapid a grower as its commoner relative. As a standard vine that will "rough it" and stand neglect and drouth, nothing is better than the Virginia creeper (*Ampelopsis quinquefolia*). This is easily started from cuttings and when once established needs no care. It is a rapid grower and has a pretty leaf, forming a dense shade. In the autumn the foliage takes on beautiful tints of crimson and scarlet after the first frosts, making it very attractive. The newer introduction of the Japan ivy, (*Ampelopsis veitchii*) has not succeeded so well under several trials by the writer, but is worthy of a trial under different conditions and where a vine is desired to cover a wall. Other climbing plants that grow well where a vine is desired are the ordinary hop, various grape vines, one of which, the Goethe, is especially suited to arbor purposes,—the moonvine, and the Madeira vine—an annual growing from tubers. Some seeds, such as the morning glory, make rapid growth for vine purposes. As an evergreen vine, nothing is better than the Japan honeysuckle, which makes a good growth and, with its deep green foliage and sweet-scented flowers, borne abundantly in the early summer, is an ornament and shade all the year round.

Shrubs and Evergreens

Many shrubs and evergreens do well in our climate. The arbor vitae succeeds admirably, but, as is true of most trees and shrubs, should be transplanted when still very young,—one year old plants are the best. The common native elder may be used to advantage in some locations and is virtually evergreen. The native flowering willow is one of the best and easiest grown flowering shrubs, and the common bird of paradise, with its profuse bloom, will grow with almost no care, and may readily be started from the seed sown in the fall.

Roses

With our sunny climate and mild winters we have conditions well suited to the cultivation of the finer roses, and failure with this queen of flowers is more often due to carelessness of handling or to the choice of varieties planted than to anything lacking in the natural conditions. Some varieties are much more susceptible than others to our summer heat and the dry air and winds. Such a one is Mad. Joseph Schwartz,—a variety usually found near the head of the list in most florists' catalogues, with strong recommendations as



"Maman Cochet" Roses, cut from two-year old plant four months after setting out being a reliable sort. This rose almost invariably, with ordinary treatment, fails to open from the bud, which dries up and drops off before maturity. Many, if not all, roses will be benefitted if afforded some slight shade from the hot sun during June and July. A separate bed should, in any garden, be assigned to the roses where they can receive the special treatment they require and deserve, and this bed may, without much trouble or cost, be covered with a light awning during the severest heat of the summer. The results will amply repay this slight trouble in the increased yield of autumn bloom, continuing until after the first frosts. A rose bed should be well manured each spring, and if the more tender varieties,—the teas—be grown, a fall top dressing of light manure or straw will be beneficial as a mulch for winter protection. The bushes should be properly pruned in the spring, before the new growth starts, and all dead wood cut out. Most roses will retain much of their foliage throughout the winter. Care should be taken to see that the soil of the rose bed does not become too dry during winter.

Do not make the mistake of planting the tender greenhouse roses offered so cheaply by florists. A few may live, after a prolonged struggle with their changed conditions, but the large majority will surely perish if set at once in the open garden. By all means, buy the two-year old plants, setting them out in February or March. If healthy stock is procured, the plants will bloom freely the first year. Unless home grown stock can be had, California grown roses are to be preferred. Care should be taken to cut out, as it appears, all growth coming from below the bud, if the plants are budded stock and not grown on their own roots.

The following varieties of the finer roses have been tested for several years and appear to do well with ordinary care. Practically all the commoner roses will do well, but they are not included in this list.

A List of Good Roses

American Beauty—(Hybrid Tea). Color—rosy crimson. A good bloomer, with fine buds on long stems. Has done well for several years in succession and is evidently one of the best roses for our climate.

Bougere—(Tea). Color—pink, with a shade of bronze.

Bon Silene—(Tea). Color—dark crimson. Makes fine buds.

Bride—(Tea). Color—white. A good bloomer.

Catherine Mermet—(Tea, Color—light pink. One of the best.

Duchess of Albany—(Hybrid Tea). Sometimes called the Red La France. Color—a deep, rich pink, with exquisite buds.

Gen. Jacqueminot—(Hybrid Perpetual). Color—dark red. A profuse bloomer and good rose.

Gen. Lee—(Tea). Color—apricot-yellow.

Hermosa—(Bourbon). Anold variety. Color—pink; medium sized flowers; very hardy.

Kaiserin Augusta Victoria—(Hybrid Tea). Color—white. A profuse bloomer, good grower and one of the best varieties to plant. Has done well for a number of years.

La France—(Hybrid Tea). Color—pink. Well known as a constant bloomer. Shows some tendency to suffer from heat but with sufficient water does well.

Madame Testout—(Hybrid Tea). Color—pink. A reliable rose.

Maman Cochet—(Tea). Color—pink. A good grower, producing the most beautiful, well-shaped, long buds onlong stalks.

Safrano—(Tea). Color—apricot-yellow. One of the few yellow teas that do well. Needs protection in a very cold winter.

Souvenir de Wooton—(Hybrid Tea). Color—crimson.

Sunset—(Tea). Color—golden yellow, tinged with copper and crimson. Not always a very strong grower but blooms profusely. Should be protected if the winter is unusually severe.

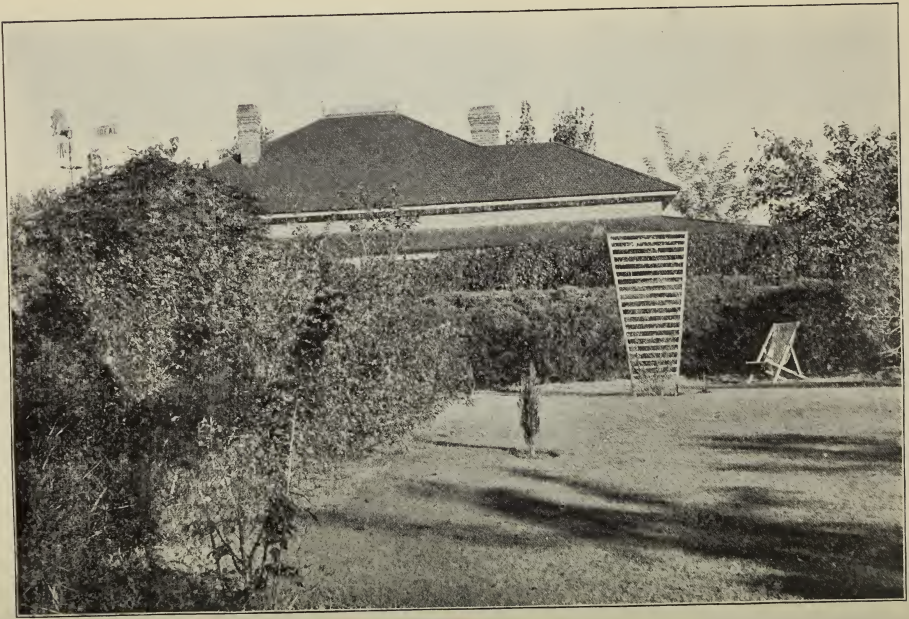
White La France—(Hybrid Tea). Called also *Augustine Guinoiseau.* Possesses the good qualities of the La France.

White Malmaison—(Bourbon). Color—white with touch of light blush. A strong grower and profuse bloomer.

Sweet Peas

Of all the annuals to be grown from seed, none will give more satisfactory results or more varied, profuse and beautiful bloom than the sweet pea. Our climate seems to be particularly well suited to the growth of this flower, and the newer varieties that have been created in recent years as a

SWEET PEAS—From fall sown seed
Queen Victoria
Prince of Wales Navy Blue



Showing in the foreground, Bermuda grass lawn, fourteen months after planting; on the left, hedge of common roses; and in the background, tamarix hedge, behind which is Virginia creeper, covering porch result of the increasing popular interest in the flower, provide a large assortment of different colors. The sweet pea is easily grown, is a most untiring bloomer, can be had in almost every color of the rainbow, and makes an excellent flower for cut blooms.

The sweet pea delights in a rich and not too heavy soil. This should be well prepared by manuring and spading some little time before sowing. Procure, if possible, native grown seed, which from careful experiments made during a series of years by the writer, will give better results than the commercial seed. Sow the seed any time from October 1st to January 1st, but the earlier the better. Seed may be sown as late as March 1st, but the spring sown seed will not give as good results as that sown in the fall, nor will it withstand as well the summer heat. Sow the seed in rows, four inches deep. A better method, though calling for more work, is to remove the soil from your seed bed to a depth of not less than four inches and scatter the seed broadcast so that the individual seeds will average about two to three inches apart in distance. An ounce of seed will thus sow 20 to 30 square feet. Cover with the soil previously removed so that the seed will be at least four inches below the surface; six inches will not hurt it, and should the soil be light, will be better. Pack down the soil over the seed well and irrigate. In two weeks or more the seed will be well started. A light protection of manure, brush, or dead leaves will help the plants through the colder weather, during which time they will make little growth above ground but will be making a good root growth to prepare for the blooming season. Early in the spring the plants will begin to make new growth and as soon as they are a foot or more high they should be provided with twigs or sticks, about two feet high, stuck into the ground between the plants. By April 1st you may be able to pick your first bloom, if the season is an early one and the seed has been sown in a protected place, and from that date to May 1st the different varieties will commence to bloom.

Experiments have shown that the sweet pea responds to the use of a fertilizer by larger and finer bloom. The fertilizer used was bat guano from the caves of J. R. DeMier, at Lava, N. M., applied very lightly before irrigating.

For early bloom, sweet peas should be sown with a southern exposure, but in such case the plants will be more liable to suffer from the summer's heat later on. For the main crop of bloom, sow the seed in the open, away from any shade,—for the sweet pea loves the sunshine. The plants will continue blooming almost all through the summer if the flowers are kept picked and not allowed to go to seed, for the more you pick, the more bloom there will be. The new creations in sweet peas, advertised by florists, will not do so well in the hands of the amateur as the older varieties, and the white-seeded varieties will germinate with difficulty under the ordinary care of the amateur, requiring, as they generally do, special management. The "Cupid", or dwarf, sweet peas, whilst mostly growing well in our climate, are not so well suited for cut blooms. The sweet pea does not, with us, grow to the height which it attains in other climates—six to ten feet. Two to four feet is the average for most varieties in our climate. Do not sow sweet peas, if you sow the seed in October, where they have grown the former season,—that is, if you sow any but mixed seed. The self sown seed will come up with the varieties you sow, thus given mixed bloom and preventing the keeping of different varieties separate.

Practically all the older varieties of sweet peas will grow well, but the following varieties may be relied upon as affording a luxuriance of bloom with ordinary care in the hands of the amateur:

White—Blanche Burpee, Sadie Burpee (black-seeded), Emily Henderson (early), Mrs. Sankey, The Bride.
White and Pink—Burpee's Earliest of All, Blanche Ferry.
Pink and Rose—Royal Rose, Pink Friar, Prince of Wales.
Red—Salopian (the best scarlet), Prince Edward of York, Firefly.
Maroon—Shazada, Othello.
Cream—Queen Victoria, Stella Morse.

Lavender—Lady Nina Balfour, Lady Grisel Hamilton, New Countess.
Blue—Countess of Cadogan, Navy Blue.
Other Colors—Fashion (a rich reddish lavender); Lovely (a delicate shade of shell pink); Maid of Honor (white, edged with violet); Gray Friar (purple stripes on cream ground).

The following is a classified list of plants and flowers that will succeed, with ordinary care, in a southern New Mexico garden, with brief cultural and other notes in each case. This list does not attempt to include all flowers that will succeed, but only those that have been tried and may reasonably be expected to do well, with ordinary treatment.

Annuals

Alyssum, (Sweet alyssum). A constant bloomer until after frost. Sow in early spring or fall. Easy of culture.
Antirhinnum, (Snapdragon). Blooms profusely in spring and early summer and may be carried through the winter out-of-doors. Sow in the fall or early spring, but preferably in the cold frame in late fall ready for transplanting the following spring, or procure plants in the spring.
Aster. Sow the seed of the native varieties in the spring or, preferably, fall.
Bachelor's Button. (See *Centaurea*).
Castor Bean (*Ricinus*). Sow in the spring—March or April,—in open places. The large variety, *Ricinus Zanzibarensis*, will produce tree-like plants, 10 to 18 feet in height, and all varieties are very ornamental. Self-sown seeds will come up the following spring. Stands drouth well.
Centaurea (Cornflower, Bachelor's Button). A hardy and easily grown flower, standing our winters well and producing an abundance of bloom in the spring and early summer. Sow the seed in the fall or in the early spring. These will bloom and the self-sown seed from the blooms will start quantities of young plants the following fall.
Convolvulus, (Morning Glory). Sow in the early spring where the vines can find some support. It will bloom all summer until after frost and will sow its own seed for the following spring. A vigorous grower that will crowd out other plants, if allowed to do so, and become nothing more than a weed.
Cornflower. (See *Centaurea*).

Cosmos. Sow seed in the spring. Blooms in the fall until after frost and if allowed to go to seed the young plants will come up the following spring in great numbers.

Daisy. (See Paris Daisy).

Escholitza (California poppy). Sow in an open place in the fall or spring, taking precautions against baking of the soil, as the seed is small. Cannot be transplanted.

Gaillardia. The *gaillardia aristata* does well, blooming freely and continuously until after frost and standing the heat and drouth fairly well. Procure plants and set out in the spring in an open location. May be raised from seed in cold frames during the fall and winter.

Larkspur. Sow the seed in the fall or spring or procure plants and set out in the spring, after which self-sown seed will germinate each fall. An easy flower to grow and an abundant bloomer during the summer.

Morning Glory. (See Convolvulus.)

Nasturtium. Sow the seed in the spring—April,—after danger from frost, where the vines can have support. May be sown where the soil is poor. Blooms through the summer but will not stand much heat.

Petunia. Sow the seed in cold frames through the winter for the following spring, or, better, procure plants and set out in spring after frosts are over. Blooms through summer and especially during the fall until after early frosts. Should have water regularly during hot weather.

Paris Daisy. Set out the plants in the spring after frost is over. A steady bloomer except during the hottest part of the summer. May be grown from seed in the cold frame.

Poppy. Sow the seed in the fall, mulching with manure or light chaff. Will not transplant. Blooms profusely during the early summer—May to July, and comes up readily from self-sown seed.

Snapdragon. (See *Antirhinnum*).

Sunflower. The mammoth Russian sunflower does well and makes a showy display of flower, whilst the many single varieties are easily grown from the seed in the open. Sow in the fall or spring. The massive seed heads of the Russian variety are valuable for poultry food.

Sweet Alyssum. (See Alyssum).

Sweet Pea. See paragraph on sweet peas on page 18.

Zinnia. Sow the seed in the fall or spring. Flowers well and continuously through the summer until after frost.

Hardy Plants and Perennials

Aquilegia, (Columbine). Set out the plants, which may be procured from most of our mountains or purchased from florists, (preferably the former, since they are already acclimatized), in the spring or fall. An open and sunny, as well as a more shady, location will suit the columbine well. Blooms during early summer. The wild yellow varieties do best, although the scarlet and other sorts may be grown with care.

Canna. Procure the roots and set out in an open, sunny, unsheltered spot after frost is over in the spring, manuring the ground well. The canna does exceedingly well in our sunny climate and blooms freely all through the summer until frost. Plant the roots about six inches deep. Stand drouth fairly well but repay irrigation with increased quantities of bloom. Like the dahlia, the roots of the canna may be allowed to remain in the ground all winter and divided and transplanted each spring.

GAILLARDIA ARISTATA. An easily and beautiful continuous blooming perennial, well suited to our climate. Photographed from flowers picked from a plant three months after setting out.

Chrysanthemum. Procure the young plants, —which may be started from slips during the spring, and plant out in a well manured bed after danger from frost. A northern exposure is to be preferred, and on account of the early frosts, the early flowering varieties should be selected. The chrysanthemum is a gross feeder and requires rich soil, though it is of the easiest possible culture. During the summer and until August, pinch back the shoots of the plants so as to induce a branching out of the new growth. When the buds appear, nip off all ex-

White and red Chrysanthumums growing in the open; November, 1901.

cept the largest at the end of each shoot, which will result in larger blossoms.

Columbine, (See Aquilegia).

Dianthus, (Pink). The hardy pinks are excellent flowers for the garden. Procure and set out in the early spring or fall or sow seed in the fall. Bloom profusely during the summer. The Sweet William, which has been much improved in recent years, is a Dianthus, and grows and blooms well.

Dahlia. Set out the roots in the spring after the heavier frosts are over, planting six inches deep. The soil should be well manured. As the plants grow, support them against winds by sticks. Bloom all through the summer until frost. The roots may be allowed to lie in the ground until the following spring, when they should be divided again.

Geranium. This common flower is best suited to winter blooming in pots or boxes in the house. Our summer heat is too severe to allow of much success with out-of-door culture. The plants should be set out of doors for the summer, in a shady place, where they can rest, and be brought in again in the fall. Easily propagated in the house from cuttings.

Gladiolus. Treat the same as dahlias or cannas. Period of blooming is short,—a month in the early summer.

Golden Glow. (See Rudbeckia).

Hollyhock. Sow the seed in the fall or procure plants and set out in the spring. They will bloom abundantly the first summer and the self-sown seed will start many young plants the same fall, which should be transplanted the following spring. The hollyhock is one of the best showy plants to adorn a garden and blooms continually until after frost.

Iris. Both the common and the German and Japan iris do well and flower profusely. Plant the roots in the fall or spring. Well suited for border planting or edging beds or walks. Every other fall the plants should be raised and the roots divided and replanted.

Peony. Grows fairly well, but suffers somewhat from the hot sun. The commoner varieties should be planted.

Pink. (See Dianthus).

Pyrethrum. Sow the seed in the fall. The older plants may be divided. Blooms continuously during the summer, standing drouth well and requiring little care.

Rudbeckia, (Golden Glow). This comparatively new flower has done exceedingly well with the author. Set out the plants in the spring, in a sunny location, procuring them from some florist. They will, with ordinary care, bloom profusely and continuously until after the first frosts, making a desirable flower for cutting, and being very showy.

Sweet William. (See *Dianthus*).

Tuberose. Planted in the open garden it succeeds fairly well, if supplied with sufficient water. Suffers from the summer heat.

Verbena. This popular and sun-loving plant is at home under southern New Mexico conditions. The plants may be grown from fall or spring sown seed, or from seed sown in the cold frame, but surer results will be obtained from plants bought and set out in the spring, April or May. With ordinary care, the verbena will bloom all through the season until well after the autumn frosts, and if given a little protection and a southern exposure will occasionally delight the amateur with winter blooms. Plant in a sunny and open place.

Violet. The violet may be successfully grown in cold frames during the winter and spring. For this purpose, as well as for ordinary open culture, the California and Princess of Wales varieties succeed as well as any. Set out the plants in the early fall or late summer, giving preferably a partially shaded location if in the open, when the plants should be afforded some protection from the frost by means of brush, etc. There are possibilities in the direction of growing violets on a commercial scale worthy of investigation, succeeding as they do with proper care, and being a ready selling flower. New plants should be started from the runners of the old ones, setting out in the spring after blooming. The violet loves a rich soil, containing as much leaf mould as can be procured.

Wallflower. Start from fall sown seed, or from seed sown in cold frames, transplanting in the spring. Will bloom the first season and thereafter each year in the early summer.

Winter Blooming Bulbs

Hyacinth. These popular bulbs do well in the open garden. Plant in October, the tops of the bulbs four inches below the surface, and keep the soil moist. Prepare the soil by manuring and spading well. The white, red and pink, and blue varieties do best, single and double. For house culture, plant in tins, (which are preferable to ordinary flower pots, retaining moisture better), in fairly rich soil, in October. Water well and put away in a cellar, or, if such is not available, bury in the ground from six inches to a foot below the surface. When the bulbs have appeared above the surface of the soil in the tins, which will be in from one to two months after planting, bring into the house. Many varieties show a tendency to bloom down in the bottom of the plant, without making sufficient leaf growth. This can be largely remedied by placing over the plant, as soon as this tendency appears, a cone of paper with the small end cut off, which will draw the plant up towards the light. A strong root growth is necessary for the best results with all winter flowering bulbs, and this can only be secured by planting the bulbs early enough to be put away and make such root growth before bringing out into the light. The old bulbs should be set out in the open after having done flowering, where they will come up and bloom the following and succeeding years.

Narcissus. The directions given for hyacinths apply to the narcissus. Almost all varieties do well in the open, better than in pots or tins in the house.

Tulips. Most varieties succeed in the open garden, especially the parrot feather varieties. They should be treated the same as the hyacinth. Have not given satisfactory results as a house bulb.

Flowering Shrubs

Althea, (Rose of Sharon). Succeeds well. Plant in the spring in open place. Blooms in the early summer. The althea should be pruned in the spring.

Bird of Paradise, (*Caesalpinia Gilliesii*). A shrub that will do well anywhere in our climate. Its beautiful heads of bloom, golden and red, make it very attractive either in single specimens or as a hedge, but for single specimens the shrub needs pruning to avoid its naturally straggling tendency.

Crape Myrtle. An excellent shrub for planting.

Elder. The native elder bush makes an attractive addition to a garden, remaining green all winter as it does. It can easily be started by taking rooted sprouts from the wild bushes, and grows easily and rapidly.

Snowball. Has succeeded fairly well. Blooms in the early summer. Prune after flowering.

Spirea. The *spirea billardii* and possibly some others of the commoner varieties appear to do well.

Syringa. Many of the syringas grow and bloom well with ordinary care. The common lilac, both purple and white are among these. Prune after blooming.

Evergreens

Arborvitæ. Plant only the young plants, one year old. Almost all varieties succeed, the golden especially. The arborvitæ is with difficulty transplanted after attaining any size.

Buxus. The common box, in several varieties, grows well, although slowly.

Cedrus deodara. Grows well and makes a most attractive tree.

Euonymus, (Tree Box). Is an attractive and beautiful evergreen.

m.)

BULLETIN NO. 41

MARCH, 1902

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

SPRAYING ORCHARDS FOR THE CODLING MOTH

BY

FABIAN GARCIA

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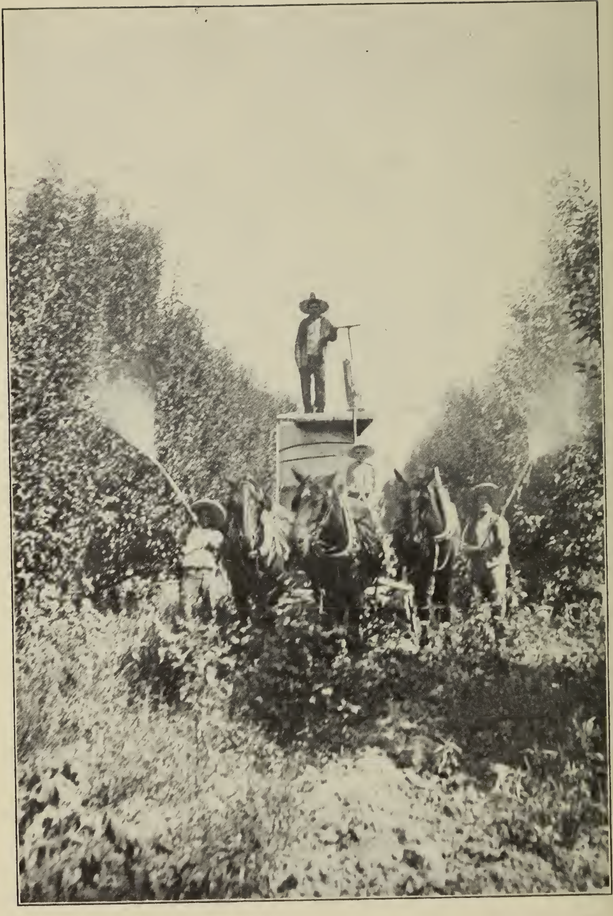
Spraying in the Experimental Station Orchard



Gould's "Monarch" Two-Cylinder Spray Pump used in the Co-operative Experiments in Mr. Frank Burk's Orchard

SPRAYING ORCHARDS FOR THE CODLING MOTH

GENERAL REMARKS

Spraying for the codling moth is now an important horticultural operation throughout the country. In the older apple growing states, spraying is taking its place along with other orchard operations, such as tillage, pruning, thinning, etc. The apple growers in most of these states realize that, in order to compete on the market with good sound apples, they must spray; otherwise, a larger per cent of the fruit will be wormy and the profits from the orchard less.

While spraying is not an absolute cure for the codling moth, it reduces the percentage of wormy apples, and seems to be the best and most economical way of fighting the insect. In all the investigations along this line, nothing has been found yet to be a complete remedy for the codling moth. Much time and money is being expended every year by many of the experiment stations in trying to find some better way of getting rid of this pest.

The codling moth seems to be the most serious drawback to the profitable growing of apples, and wherever apples are grown on a commercial scale, sooner or later, this insect is going to be a source of trouble to the apple growers. The amount of damage done by this pest is enormous. It has been estimated that from 25 to 75 per cent of the apples is destroyed in all countries where the insect is not checked in its work. In the state of New York alone, where many of the apple growers continuously fight the codling moth, it is estimated that about one-third of the crop of apples is wormy, and this means that the state loses about $2,500,000 worth of apples every year.* These figures give an idea of the amount of damage this insect does in one state.

In New Mexico, too, the codling moth is getting to be a very serious pest. This insect made its advent into the territory just about ten years ago. And, while there are yet a few apple growing districts free from the codling moth, it is getting to be very bad wherever it has been introduced; every year the production of sound apples is being reduced, and unless the ravages of this insect are checked, the apple industry of the territory is likely to suffer.

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*Cornell Univ. Bulletin 142, by M. V. Slingerland.

Throughout New Mexico the subject of spraying has received, as yet, little or no attention, and in some cases it has even been condemned as being of no value. This latter view has probably arisen from the negative results of some improper spraying, conducted by a few individuals here and there, or from results obtained during years of poor crops. The time is coming when our apple growers will have to spray, if they expect to have any considerable amount of sound fruit. Many of the large orchardists in this locality have had very little faith in spraying, and, consequently, they do not attempt to save the crop; the result is, that a very large per cent of the crop is "stung"* every year. The past season the station conducted a series of spraying experiments, with a view of ascertaining, principally, if spraying really does any good. The results of this work, while not conclusive, are very encouraging, and show that spraying will reduce the percentage of stung or wormy fruit very materially.

In the present bulletin it is intended, first, to treat the subject under consideration in a general way, giving such information as will enable the apple grower of the territory to fight the codling moth, which is now demanding attention; and, second, to give the results of the past year's investigations. Much of the information given can be found in similar works from other stations. The part treating of the results of the investigations, it is hoped, will be encouraging and helpful to the apple growers of the territory. Furthermore, it is hoped that the facts herein presented will be assurance enough of the value of spraying for the codling moth in this section.

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*The word "stung" as used in this bulletin means exactly the same as "wormy."

THE CODLING MOTH

There are two classes of insects as regards their eating habits, one of which includes the sucking insects, and the other, the biting or chewing ones. To the latter class belong such insects as the grasshopper, many beetles, and the codling moth. The surest remedies for these insects are the direct poisons, such as Paris green, or other compounds containing arsenic, which can be applied to the part of the plant eaten by the insect. Red spider, scale insects, wooly aphis, and other plant lice are good illustrations of the sucking insects, which insert their mouth parts into the plant tissue, and draw out the sap of the plant. Such insects can not be killed with a direct poison, but the remedy must be one that kills by contact with the insect body, such as kerosene or kerosene emulsion. It is important that the apple grower should become acquainted with the eating habits of the more common injurious insects, as sometimes it is somewhat puzzling to know which mixture to use for the insect causing the trouble. The codling moth, being a chewing insect, is killed by a direct poison.

The number of broods of the codling moth determine, to a large degree, the amount of damage done in a given locality. This number depends on the climatic conditions. Usually in warmer sections, with long seasons, there are more broods, and consequently the damage to the crop is greater. At Mesilla Park the damage to the apple crop, due to the codling moth, is very considerable, doubtless, on account of so many broods. A summary of the life history of the codling moth at Mesilla, three miles west of Mesilla Park, is given in Station Bulletin No. 25, by Professor T. D. A. Cockerell, formerly entomologist of the New Mexico Experiment Station, and it is as follows:

"Summary of Life-History in Mesilla"

"The moths from overwintered worms appear towards the end of April, and lay their eggs on or near the small apples. The young worms can be found in small numbers about the second week of May, and by the latter half of May are numerous. By the end of May about 4 per cent. of the worms have matured, and have left the apples to spin up under the bark, or bands if such have been provided. By the end of the first week of June quite a number of worms have spun up, and by the middle of June they are mostly out of the apples. The worms become pupae in their hiding places, and the moths begin to emerge about the last week of June, some no doubt earlier. By July 3rd the second generation of worms, resulting from the last mentioned moths, may be found in the apples, and by July 10th it is in full force, the worms being mostly about half-grown. Quite a number of the second generation are more advanced, and by the middle of July plenty can be found under the bands. These result in moths, and by the end of the second week of August small worms of the third generation are in the apples, while nevertheless late members of the second generation are still under the bands. At the end of the third week of August the early members of the third generation have spun up, and some are even pupae; so that the broods are now scarcely separated, the latest of the second generation being little in advance of the earliest of the third. Moths again appear during the latter half of August, and in September, and a partial fourth generation of worms results from them, but a large proportion of the larvae or worms of the third generation winter as such, to give moths next spring."

So it seems from the above life history of the insect that there are not only a large number of broods, but that they are quite irregular in their appearance. They seem to overlap, and in this way it is a difficult matter to spray at any regular time. This brings up the question of

SPRAYING.

When to Spray

When to spray, or how often we should spray, is a question that is not settled for this section. No fixed time can be given for the sprayings. Of course, if the sprayings do not come too close together, it seems best, they should be given just before the different broods are in full force. The results of the past season show that the oftener the spraying the better.

Eastern as well as western authorities on the subject recommend that the first spraying shall be done soon after the blossoms fall, and that the second spraying should occur a week or ten days later and before the calyx closes. The reason for this treatment is that, since most of the worms enter the apples through the blossom end, (this fact, however, does not agree with the observations at Mesilla Park), it is very necessary to get the poison into the calyx-cup before it closes, in order that when the worm is ready to go into the apple, it may eat enough poison to kill it before damaging the fruit very much. In this connection, Professor M. V. Slingerland, of Cornell University, in bulletin No. 142 says: "It is necessary to success to get a dose of poison into the blossom end of the young fruit soon after the petals fall, and before the calyx lobes have drawn together." Again he says: "The sole aim of the fruit-grower should be to have a dose of Paris green in the calyx-cup when it is covered by nature."

It is a well established practice that two sprayings—one after the petals fall and the other about a week later—are enough, for the eastern portion of the United States, where there are not over two broods of insects each year. In the western states conditions are different and opinions differ on this point. Where the insects produce more than two broods,* it is necessary to spray more than twice. How much more, and how often are questions not yet settled. Professor Close, formerly of the Utah Experiment Station, in Bulletin No. 65, recommends five sprayings and even the sixth, about the first of September, will be beneficial. In Oregon, some of the experimenters have been led "to conclude that even six or seven applications can be made with profit." Professor A. B. Cordley, in Bulletin No. 67, just published, says: "Persistent, intelligent spraying should give 85–90 per cent of fruit free from worms." While Professor Wickson, of Berkeley University, in his "California Fruits" recommends two or three sprayings for late apples. At Mesilla Park, an Arkansas Black tree, sprayed only four times, gave over 30 per cent more sound apples than a similar tree, not sprayed. From the results of last year's investigation, we are led to believe that, to get satisfactory results with late apples, it is necessary to spray more than three times during good crop years. And, also, that the eastern rule of spraying only twice, and that before the calyx-cup closes, may not be satisfactory. Tne fact that most of the worms enter the apples through the side in this region, seems to indicate that the early sprayings could be given later than immediately after the blooms fall. Personally, I am of the opinion that with our conditions, it is not necessary to spray early in order to get the poison into the calyx-cup before it closes. However, this is a point for further investigation.

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*Professor A. B. Cordley of the Oregou Experiment Station, in speaking of the number of broods says: "There are but two annual broods not three or four as has been stated."

How to Spray

This is an important feature in spraying. Every year there is a great deal of spraying that does very little good. Many individuals go through the operation and simply waste time and money. I have observed that unless the operator is very careful there will be fruits, and even large areas, on the tree, left unsprayed. In many cases the operator sprays the lower limbs of the tree heavily, but the topmost twigs, and even the center, are left dry, and then he wonders why spraying does not produce better results. The experience of the writer in spraying in the Station orchard has been that, better work can be done by beginning with the topmost limbs and working down through the center of the tree to the outer and lower limbs, especially in heavily foliaged trees. If spraying is done at all, it should be done thoroughly. It does not pay to half way do the work. When thoroughly sprayed, the tree should be wet all over, though, not necessarily dripping.

Spraying Not Satisfactory

The Department frequently hears of complaints, from fruit growers, of the inefficiency of spraying in their orchards. The poor results obtained from spraying in such cases may be due to one or all of the following causes: Impure poison, improper making or mixing of the solution, poor machinery, improper work, not enough applications, or a small crop of apples.

Pump and Nozzles

The best work can be done only with the best machinery. A poor spray pump is like any other poor implement. Some of the most desirable features of a good pump are durability and strength, a good agitator, a large air chamber, so as to keep a strong and steady stream, and above all it should work easily. The parts that come in contact with the spraying solution should be of brass, so as to last longer. If it is a barrel pump, the barrel should have a removable top, something on the style of the one described by Professor Paddock in Bulletin No. 121, Appendix, of the New York Agricultural Experiment Station.

A nozzle that throws a medium fine spray seems to be the best. The Cyclone, Calla, Vermorel, Seneca, and Bordeaux nozzles were tried in the Station orchard last year. The Bordeaux nozzle gave the best satisfaction, and was the one used last year in spraying the apple trees.

The fruit grower, before buying a spray pump, should carefully study the different pumps offered for sale by the manufacturers of these apparatus. Much information can be had from this as well as other Experiment Stations, on spraying pumps, which may enable the buyer to select one that best suits his conditions. Among the better known makers of spraying pumps and their attachments may be mentioned the Gould's Manufacturing Company, Seneca Falls, New York; Field Force Pump Company, Lockport, New York; and the Deming Company, Salem, Ohio.

Poisons to Use

Any of the arsenites can be used, but here again, orchardists differ widely in opinion as to the best poison. Paris green and London purple have been very common poisons in the past. While London purple is less used than formerly, Paris green is still very extensively used. Some drawbacks to the use of Paris green are that it settles readily, is quite expensive, and frequently is adulterated. On the other hand, it is easily prepared for use.

White arsenic, which is used in the form of arsenite of lime and soda, is a purer and cheaper poison than Paris green, and is rapidly being substituted for it. Arsenic, in a soluble form, is very injurious to the foliage, and therefore it must be used with lime. Lime is used with all of these poisons, to keep them from burning the foliage, and to help to hold the poison on the leaves and fruit longer.

Great care must be taken in the use of these arsenicals, as they are very poisonous. Precautions should always be taken not to endanger the life of man or beast by leaving the poison in accessible places. It should be kept in some safe place, and labeled "*Poison.*"

Preparation of the Mixtures

Paris green and *London purple*—Both of these are used in the same strength solutions, and prepared in the same way. Lime must always be used to prevent the burning of the leaves. The mixture is prepared as follows :

Paris green or London purple	1 pound
Fresh slaked lime	2 to 4 pounds
Water	150 to 200 gals.

A good way is to make a paste of the poison in a little water, slake the lime, and then add both to the water in the barrel. If it is necessary strain the lime, so not to clog the nozzel. The mixture must be vigorously agitated, while spraying, to keep the Paris green and lime from settling to the bottom. In this way a constant flow of poison will be kept up. Be sure to use enough *good* lime, as this prevents the burning of the leaves.

Arsenite of Lime

There are two ways of using this poison, one with lime alone, the other with sal soda and lime.* The poison was used both ways in the station orchard last year. The arsenite of lime is prepared as follows:

White arsenic	1 pound
Fresh slaked lime	2 pounds
Water	2 gallons

Slake the lime and mix in the arsenic and boil together for forty-five minutes, stirring occasionally. Use two quarts of this stock solution and one pound of freshly slaked lime to every fifty gallons of water. The objectionable feature of this formula is that one can not tell when all the arsenic has been dissolved and combined with the lime. In keeping the stock solution, in large quantities, the arsenic and lime will settle to the bottom of the vessel, and leave a clear looking liquid on top. For this reason it becomes necessary, every time any is to be used, to thoroughly mix the solution before taking any out.

Arsenite of Soda

This is a more satisfactory mixture to work with than the last mentioned one. It takes less time to prepare it, the arsenic dissolves more quickly, one can tell when it is dissolved, and there is no settling of the arsenic when the stock solution is allowed to stand.

White arsenic	1 pound
Sal soda (washing soda)	4 pounds
Water	2 gallons

Put all together and boil for fifteen or twenty minutes when the arsenic will be dissolved and the liquid will have a dirty appearance. Replace the water lost in boiling. With every fifty gallons of water use two quarts of the stock solution and two pounds of freshly slaked lime. These stock solutions should be kept covered to prevent evaporation.

Do not throw any of this solution on the ground near trees, as it is likely to injure, if not kill them. Last fall, while preparing this mixture with one of the students in special agriculture, a lot of the solution was thrown on the ground near two elm trees and under a mulberry tree. Two days later our attention was attracted to these trees by the dying of the leaves. In the case of the mulberry tree, the side next to where the solution was thrown out died, while the opposite side is still living. The two elm trees have also died. The same thing was noticed in Mesilla, in Dr. Bailey's orchard. He had thrown some of the arsenic solution on the ground under an apple tree. The limbs and leaves, on the side next to the place where the solution had been thrown out, were dying when the writer saw the tree.*

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*Close, C. P. Utah Exp. Sta. Bul. 65.

Become Acquainted with the Moth

Every orchardist who has wormy fruit soon learns to know the little creature that does the damage to his apples. He knows it as a small pinkish-white worm. But few of the fruit-growers ever become acquainted with the moth that produces this destructive little worm. Since the moth is nocturnal in its habits, few people, indeed, become familiar with it. If one wishes to become acquainted with the moth, catch a few worms and put them in a bottle, put a few pieces of paper in with them, and cover the bottle with some wire gauze. In about twelve or fifteen days some of the worms will have developed into small brownish moths, with very noticeable dark brown spots, streaked with bronze, near the hind angle of the front wings.

TESTS AT THE EXPERIMENT STATION

Until the present, data on the subject of spraying apple orchards for the codling moth in New Mexico, have been wanting. Since only such data could answer the many conflicting opinions and settle, at least, partially the question as to the value of spraying in this section, a series of experiments for the codling moth were commenced at the Station orchard, and in co operation with Mr. Frank Burke, of La Mesilla.

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*Dr. Bailey has since informed me that the tree is dead.

Object of Experiments

1st—To ascertain if spraying really did any good, and if so, to what extent.

2nd—To find out best number of sprayings.

3rd—To ascertain per cent of fruit stung through the calyx, and through the side.

4th—Cost of spraying.

5th—Test of Paris green, arsenite of lime, and arsenite of soda.

6th—Value of spraying and banding.

Plan of Treatment

Five varieties of winter apples were taken for the work at the Station,—the Gano, Ben Davis, Arkansas Black, Nickajack, and Kentucky Red Streak. The Red June, an early variety, was sprayed during the previous season, but the results are reported in this bulletin. In each series of the experiments there were three trees and each tree was treated differently from any other tree in that series. There was also a tree left untreated, as a check.

Gano sprayed with Paris green:

1st tree once every two weeks
2nd “ “ “ three weeks
3rd “ “ “ four weeks
4th “ left untreated (check). *

Gano sprayed with arsenite of lime:

1st tree once every two weeks
2nd “ “ “ three weeks
3rd “ “ “ four weeks
4th “ left untreated (check). *

Gano sprayed with arsenite of soda:

1st tree once every two weeks
2nd “ “ “ three weeks
3rd “ “ “ four weeks
4th “ left untreated (check). *

Arkansas Black sprayed with arsenite of soda:

1st tree once every week
2nd “ “ “ three weeks †
3rd “ “ “ five weeks †
4th “ left untreated (check).

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* The same tree for all the Ganos.

† Second spraying omitted.

Nickajack sprayed with arsenite of soda:

1st tree once every week
2nd " " " three weeks
3rd " " " five weeks
4th " left untreated (check).

Ben Davis sprayed with arsenite of soda, and banded:

1st tree once every two weeks, banded
2nd " " " three weeks, banded
3rd " " " four weeks, banded
4th " left untreated (check).

Ky. Red Streak sprayed with arsenite of soda, and one tree banded:

1st tree once every two weeks, banded
2nd " " " " ", not banded
3rd " left untreated (check).

Red June, sprayed with arsenite of lime:

1st tree once every week
2nd " " " two weeks †
3rd " " " four weeks †
4th " left untreated (check).

History of Test

All the varieties but the Nickajack produced a good crop of fruit. The size of the crop makes a great difference in the final results in spraying. If the crop is small, spraying apparently does very little good. The apples on the tree were undersized, due principally to the drought, as there was no water for irrigation during the summer.

This affected the size of the apples, but not the size of the crop of worms. The trees sprayed are not very large, and it usually took two gallons of solution to get each wet, and about four to five minutes to spray each. Of course the amount of liquid and time necessary to spray each tree depends, largely, on the size of the tree, and, consequently, no fixed rule can be followed in this respect. In doing the spraying, particular care was taken to spray the top-most limbs, as well as the center of the tree—the parts frequently left dry by beginners. The rule given for the eastern states is to spray the first time soon after the petals fall, and again about a week later, in order to get some poison into the calyx-cup before it closes. This rule was followed, with the trees not sprayed every week, except in two cases. In these two cases, (two trees each of Red June and Arkansas Black) the second spraying was not given. There seems to be no noticeable difference in the results that might be due to the omission of this second spraying.

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†Second spraying omitted.

In order to ascertain what part of the whole crop of apples produced by the trees is destroyed by the moth, and to find out the per cent of the wormy fruits stung through the calyx and through the side, all the fruit produced by each tree, including windfalls, was counted and carefully examined. The windfalls were gathered and counted three times during the season. The apples on the trees at the time of picking, were also counted and examined. The number of gallons of spraying mixture used on each tree for the season was recorded. The cost per barrel of the different spraying mixtures used is given below, as well as the price of the spraying material.

White arsenic, in Chicago, 10 pound lots, 8c per pound
Paris green, in Chicago, 28 pound lots, 16c per pound
Sal soda, in Chicago, 125 pound kegs, $1.65 per keg
Lime at F. H. Bascom Co., Las Cruces, N. M., 50c per 100 pouuds.

Paris Green Mixture

Paris green, 4 ounces	4c
Lime, one pound	½c
Total cost per barrel	4½c

Arsenite of Lime

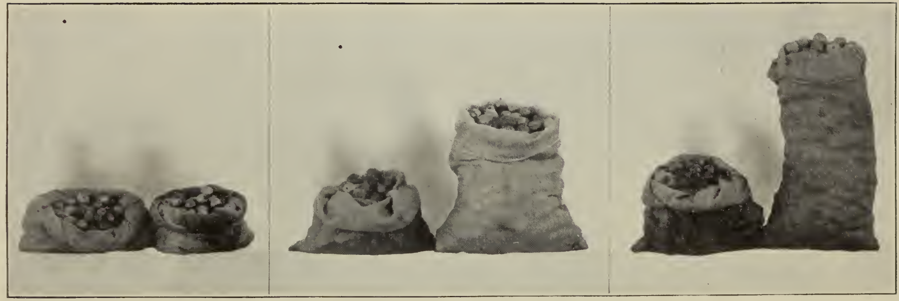
White arsenic, 4 ounces	2c
Lime in stock solution, ½ a pound	¼c
Freshly slaked lime, 1 pound	½c
Total cost per barrel	2¾c

Arsenite of Soda

White arsenic, 4 ounces	2 c
Sal soda, 1 pound	1⅓c
Freshly slaked lime, 2 pounds	1 c
Total cost per barrel	4⅓c

TABLE I

NAME.	POISON USED.	SPRAYED.	DATES OF SPRAYING
Gano	Paris Green	Every 2 weeks	4-30: 5 10: 5-24: 6-7: 6-21: 7-5: 7-19; 8-2: 8-16; 8-30
"	"	" 3 "	4-30: 5-10; 5-31: 6-21: 7-12: 8-2; 8-23.
"	"	" 4 "	4-30; 5-10; 6-7; 7-5: 8-2; 8-30.
"	Arsenite of lime	" 2 "	4-30; 5-10: 5-24: 6-7: 6 21; 7-5; 7-19: 8-2: 8-16; 8-30.
"	" "	" 3 "	4-30; 5-10: 5-31: 6-21: 7-12: 8-2; 8-23.
"	" "	" 4 "	4-30: 5-10: 6-7; 7-5; 8-2: 8-30.
"	Arsenite of soda	" 2 "	4-30: 5-10: 5-24: 6-7: 6 21: 7-5; 7-19; 8-2: 8-16; 8-30
"	" "	" 3 "	4-30; 5-10; 5-31; 6-21; 7-12: 8-2; 8-23.
"	" "	" 4 "	4-30: 5-10: 6-7; 7-5: 8-2: 8-30.
"	Untreated—	Chech tree	for all three series.
Ark. Black	Arsenite of soda	Every week	5-10: 5-17; 5-24; 5-31; 6-7; 6-14: 6-28: 7-5: 7-12; 7-19; 7-26: 8-2: 8-9; 8-16; 8-23: 8-30.
"	" "	Every 3 weeks	5-10; 5-31; 6-21; 7-12; 8-2: 8-23.
"	" "	" 5 "	5-10: 6-14; 7-19; 8-23.
"	Chech tree		
Nickajack	Arsenite of soda	Every week	4-30; 5-10: 5-17; 5-24: 5-31; 6-7: 6-14; 6-28: 7-5; 7-12; 7-19; 7-26; 8-2; 8-9; 8-16; 8-23; 8-30.
"	" "	Every 3 weeks	4-30; 5-10; 5-31: 6-21; 7-12; 8-2; 8-23.
"	" "	" 5 "	4-30; 5-10: 6-14; 7-19; 8-23.
"	Chech tree		
Red June	Arsenite of lime	Every week	4-24: 5-1; 5-8: 5-15: 5 22; 5-29; 6-5; 6-12; 6-19: 6 26.
"	" "	Every 2 weeks	4-24. 5-8; 5-22: 6-5; 6-19.
"	" "	" 4 "	4-24; 5-22; 6-19.
"	Chech tree		
Ben Davis	Arsenite of soda	" 2 "	4-30; 5-10; 5-24; 6-7: 6-21; 7-5; 7-19: 8-2; 8-16: 8-30.
"	" "	" 3 "	4-30; 5-10; 5-31: 6-21; 7-12; 8-2; 8-23.
"	" "	" 4 "	4-30; 5-10; 6-7; 7-5; 8-2; 8-30
"	Chech tree		
Ky. Red Streak	Arsenite of soda	" 2 "	4-30: 5-10; 5-24; 6-7, 6-21; 7 5: 7-19: 8-2; 8-16; 8-30.
" "	" "	" 2 "	4-30; 5-1 ; 5-24; 6-7: 6-21; 7-5; 7-19; 8-2; 8-16; 8-30.
" "	Chech tree		



Stung Sound
Not sprayed

Stung Sound
Sprayed every three weeks

Stung Sound
Sprayed every two weeks

Showing Proportion of Stung and Sound Fruit
Gano Trees Sprayed with Arsenite of Lime

TABLE I (Continued)

Picked........	Number of fruits				Windfalls				Total Crop Pro.			Gallons of mixture used........	Banded..........
	from Tree	Per cent sound	Per cent stung on calyx....	Per cent stung on side.....	from Tree	Per cent sound	Per cent stung on calyx....	Per cent stung on side.....	by Tree	Per cent sound	Per cent stung		
10-4	360	78.88	5.27	15.83	169	15.97	37.27	46.74	529	58.80	41.20	20	
10-4	535	69.34	9.90	20.74	173	10.40	17.91	71.67	708	54.94	45.05	14	
10-4	839	63.16	12.03	24.79	369	14.28	18.40	67.30	1203	48.37	51.62	12	
10-3	1350	66.66	15.55	17.77	949	27.61	19.17	53.21	2299	50.54	49.45	20	
10-3	917	65.43	16.03	18.53	690	18.69	22.46	58.84	1607	45.36	54.63	14	
10-3	424	55.66	12.97	31.36	351	13.39	22.79	63.81	775	36.51	63.48	12	
10-3	1228	75.97	10.42	13.59	225	20.88	19.55	59.55	1453	67.45	32.55	20	
10-2	681	80.02	5.28	14.69	95	11.57	12.63	75.78	776	71.64	28.35	14	
10-2	927	74.43	7.76	17.79	388	20.87	16.23	62.88	1315	58.63	41.36	12	
10-3	544	47.42	28.67	23.89	482	7.46	32.57	59.95	1026	28.65	71.34		
10-1	1382	83.64	4.86	11.50	121	19.83	11.57	68.59	1503	78.50	21.49	34	
10-1	899	55.85	15.01	29.14	287	8.01	12.19	79.79	1186	44.26	55.73	12	
10-1	420	66.66	6.42	26.90	311	8.03	9.97	81.99	731	41.72	58.27	8	
10-1	230	35.21	26.08	36.69	99	2.07	16.16	81.81	329	25.22	74.77		
9-28	75	61.33	10.66	28.00	84	8.33	21.42	70.23	159	33.33	66.66	36	
9-28	70	18.59	25.71	55.71	44	......	13.63	86.36	114	11.40	88.59	14	
9-28	42	14.29	9.52	76.19	129	3.10	6.97	89.93	171	5.84	94.15	10	
9-28	15	6.66	40.00	53.33	65	......	7.69	92.30	80	1.25	98.75		
7-3	1104	98.46	18.00	1.35	46	84.78	4.34	10.86	1150	97.90	2.08	22	
7-3	1613	97.45	.24	2.29	41	78.04	2.43	19.51	1654	96.97	3.02	10	
7-3	618	93.68	.64	5.66	15	66.66	13.33	20.00	633	93.04	6.95	6	
7-3	514	88.32	1.75	9.92	15	46.66	46.66	6.66	529	87.14	12.85		
9-30	1837	82.41	6.20	11.37	396	29.03	16.66	54.29	2233	72.95	27.04	20	Banded
9-30	820	71.95	8.41	19.63	404	23.76	16.09	60.14	1224	56.04	43.95	14	Banded
9-28	924	64.95	12.86	22.18	688	16.42	16.71	66.87	1612	44.23	55.76	12	Banded
9-28	760	52.10	17.89	30.00	651	8.90	22.24	68.86	1411	32.17	67.82		
10-2	727	78.54	12.10	9.35	280	15.71	38.91	45.35	1007	61.07	38.92	20	Banded
10-2	148	62.83	17.56	19.59	174	10.91	47.12	41.95	322	34.77	65.21	20	
10-2	303	53.46	28.38	18.15	231	6.06	43.72	50.21	534	32.96	67.04		

A study of the table reveals some interesting facts. In the first place it is seen that there is a large number of windfalls and that an exceedingly large per cent of these are wormy. Indeed, it is surprising how many of the apples that fall are stung by the worm. The proportion of windfalls on the unsprayed trees, as a rule, was larger than on those sprayed, and over 90 per cent of them was wormy, except in the Red June. The proportion of windfalls seems to decrease, as a rule, as the trees get more sprayings. There is a smaller per cent of wormy fruit among the windfalls from the sprayed trees, than from the unsprayed ones. The per cent varies somewhat, however, usually from 70 to 90. The trees receiving the largest number of sprayings show, as a rule, the largest per cent of sound fruit among the windfalls. It is also seen that, on the whole, a small percentage of the windfalls were stung through the calyx. Most of the worms entered the fruit from the side. One of the Red June trees was an exception.

The codling moth practically destroyed from 65 to 95 per cent of the total crop of apples produced by the unsprayed winter trees, while the sprayed winter trees, except the Nickajack, show practically 35 to 75 per cent of sound fruit of the whole crop; usually the more sprayings the more sound fruit produced by the trees.

In the case of a small crop on the trees, spraying seems to do very little good, as is shown by the Nickajack trees. These trees produced a small crop, and with the exception of the tree sprayed every week, the percentage of sound fruit was exceedingly small. By examining the table, it is seen that the Nickajack tree sprayed every week had over 61 per cent of sound fruit at the time of picking, while the tree sprayed once every three weeks had only 18 per cent. The tree sprayed once every five weeks had slightly over 14 per cent of good apples, and the check tree gave practically 6 per cent. From these facts and observations made in Mr. Frank Burke's orchard, we are led to believe that during years of small crops, we may expect poor results from spraying, except, perhaps, in the case where the spraying is done every week. The question comes up as to the advisability of spraying during "off years." If the crop is as small as it was in the case of the Nickajack this year and if there is the usual amount of worms, spraying in this section will do very little good. To have over 80 per cent of wormy fruit on the trees after spraying seven times during the season, as shown by the Nickajack tree sprayed every three weeks, is not very encouraging.

To illustrate how it may be that when there is a small crop of apples on the trees the results from spraying are not satisfactory, we may take the Nickajack tree sprayed every three weeks. Seventy apples were picked from this tree, fifty-seven were wormy and thirteen sound. A certain number of worms destroyed the fifty-seven apples and if there had been more worms, no doubt there would have been less sound apples on the tree. Now, if the tree had produced 280 apples, for example, and the same number of worms as destroyed the fifty-seven apples on the first tree, it is likely that there would have been about 223 sound apples on the tree. Of course, it must be remembered that in this instance there are no facts to show that such would be the case.

Fruit Picked From The Tree

In columns 6, 7, 8 and 9 are given the figures which really appeal more directly to the fruit grower. As a rule, he is more interested in the quantity and quality of fruit picked than in the amount of windfalls, etc. In column 6 will be found the amount of fruit picked from each tree, while 7, 8 and 9 show the per cents of fruit that was sound, that was stung in the calyx, and that was stung on the side, respectively. It is seen in column 7 that the Gano tree, sprayed every three weeks with arsenite of soda, gave about 4 per cent more sound fruit than the three sprayed every two weeks, while in the case of the Arkansas Black the tree sprayed every five weeks practically gave ten per cent more good fruit than the tree sprayed every three weeks. However, aside from these two instances, the trees sprayed oftenest in each series show the largest per cent of sound fruit, while the trees receiving the least number of sprayings show the smallest per cent of sound fruit. A very interesting point in this connection, and the one that would naturally be expected, is the fact that the untreated trees in each series gave the lowest per cents of sound fruit. Leaving out the Nickajack and the Red June, in no case, do the unsprayed trees show a higher percentage of sound fruit picked, than any of the treated trees. Thus it is seen that spraying is beneficial. The untreated trees of winter varieties that produced a good crop had practically half of the fruit wormy. The untreated Red June gave over 88 per cent of sound apples.

Another fact revealed by the figures is that in every sprayed winter tree but one (the first Ky. Red Streak) the larger number of apples picked were stung on the side. This is also true of the Red June. Even among the untreated trees, in the majority of cases, the worm did more damage to the apples picked, through the side than through the calyx. In the east it has been observed that over 3-4 of the worms enter the apples through the calyx. Speaking in this connection, Professor Slingerland§, of Cornell University says: "We soon found, as have other observers, that from 75 to 85 per cent of the worms which hatch in the spring enter the apples through the bloom end." The results of last year's investigations show that such is not the case here. From the above facts and as previously remarked, it seems that it would not be any more necessary to give the first two sprayings in order to get the poison in the calyx-cup before it closes, as is done in the east, than to spray later, just before the first brood of worms are in full force, to cover the side of the apples with the poison.

Early Apples and the Moth

The early apples are comparatively free from the codling moth. The wormy apples seem to be the result of the work of the early brood of worms. Most of the early varieties are usually picked by the time the second brood of worms is in full force, and thus they escape the ravages of the later broods, which are so destructive to the fall and winter varieties of apples. By referring to the table it will be seen that from the unsprayed tree, over 88 per cent of sound fruit was picked, while the tree sprayed three times had over 93 per cent good fruit. The tree sprayed five times gave over 97 per cent sound fruit, while there was slightly over 98 per cent sound apples picked from the tree sprayed eleven times. The trees receiving the most sprayings show the highest per cent of sound fruit. These data raise the question as to whether it is worth while to spray early apples or not.

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§Bulletin No. 142, Cornell Univ.

The early apples, as do most of the winter varieties, show that the smallest per cent of worms entered the fruit through the calyx. The Red June tree not sprayed had 9 per cent of the fruit stung through the side, and less than 2 per cent through the calyx. This indicates that even the worms from the first brood prefer to enter the apple from the side. Since the unsprayed tree had no poison in the calyx-cup, it cannot be said that the worms were killed in entering the apples.

Spraying and Banding

The three Ben Davis sprayed trees were banded and examined every week. A large number of worms were usually found under the bands. These worms generally gather in colonies under the bands. It was a somewhat difficult matter to keep an accurate account of the worms under the bands; as frequently the Woodpeckers ate the largest colonies of worms through the paper bands.

In comparing the results of the sprayed and banded Ben Davis trees with those of the Gano sprayed with arsenite of soda, it will be seen that the Ben Davis tree sprayed every two weeks shows a gain, in the fruit picked, of over 6 per cent sound apples over the Gano tree similarly sprayed but not banded. The other two Ben Davis gave lower per cents of fruit than the corresponding Gano trees. On the other hand, the Kentucky Red Streak banded and sprayed tree shows a gain of 15 per cent sound fruit over the tree only sprayed. In this case there is quite a gain, probably due to the band.

Insecticides

The Gano apple was the variety taken in the test of the poisons. A comparison of the results of the three spraying mixtures used, shows no very marked difference, especially between the Paris green and arsenite of soda. On the whole the Gano trees sprayed with arsenite of soda gave the highest per cent of sound fruit while those trees sprayed with the arsenite of lime gave the lowest per cent of good fruit. The Paris green, while not so good as the former, gave better results than the latter.

It must be remembered that the results given in this bulletin are the work of one year's investigations, and the other years may give somewhat different results.

SPRAYING EXPERIMENTS IN MR. BURKE'S ORCHARD

In cooperation with Mr. Frank Burke, of La Mesilla, the station started an experiment in spraying. Mr. Burke's orchard is about three and a half miles southwest of the station, and it contains about thirty acres. It is planted mostly to Ben Davis and Mammoth Black Twig apples, and the trees are in excellent condition. The previous year the trees produced a large crop of apples, but this season the crop was small. The spraying in this orchard was started on a regular commercial basis, so that the cost of spraying an orchard, the size of this one, can be given. Experimental spraying is always more expensive. Arsenite of soda was the only spraying mixture used.

The first spraying was given after the blossoms had fallen, but before the calyx-cups had closed. On the 3rd day of May the first spraying was commenced with two barrel pumps and four men, emptying eighteen barrels of solution daily. It took five days to spray the whole orchard, and ninety barrels of solution.

The following is the cost of the first spraying:

Four men, five days at 75c per day	$15 00
White arsenic, at 10c per pound, 4 oz. per barrel, ninety barrels.	2 25
Sal soda, at 3c per pound, one pound per barrel, ninety barrels.	2 70
Lime, at ½c per pound, four pounds per barrel, ninety barrels.	1 80*
Total	$21.75

The second spraying was done with Gould's "Monarch" Two-Cylinder spray pump. This pump was mounted on a 500 gallon tank and had two lines of hose. On the 18th of May, the second spraying was commenced, and it took three men seven days to spray the whole orchard. The cost of the second spraying was 75 cents more than the cost of the first spraying. The same amount of materials were used.

The third spraying was only partially given. It was commenced on the 16th of July, but owing to some showers and heavy irrigation of the orchard, which kept the ground too wet, the spraying was not finished.

Being an "off year" for fruit in this orchard, and having been given but two sprayings and a partial third, the results were not so good as they might have been, if more sprayings had been given, and a larger crop of fruit had been produced. Mr. Burke has sprayed his orchard for a number of years, and in regard to spraying he says: "I have sprayed my orchard for four years in succession, and feel sure it pays me to do so."

A small section of the orchard was set aside for more detailed observations. A few trees in this section were left unsprayed, while some were sprayed twice, three, and four times, and the following are the results:

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*Used two pounds per barrel more than ordinarily.

TABLE II.

Variety.	Number of trees.	Number of sprayings.	Fruit Picked.				Windfalls.				Total crop produced.			
			Total number of	Number sound.	Number stung on calyx.	Number stung on side.	Total number of	Number sound.	Number stung on calyx.	Number stung on side.	Number sound.	Number stung.	Per cent sound.	Per cent stung.
Ben Davis................	11	None	58	17	20	21	301	17	105	179	34	325	9.47	90.52
" "	10	2	385	159	67	159	299	18	84	197	177	507	25.81	74.19
" "	8	3	437	210	76	151	348	18	107	223	228	557	29.09	70.96
" "	8	4	333	177	34	122	293	20	77	196	197	429	31.98	81.02
Mammoth Black Twig...	5	None	10	3	3	4	125	1	51	73	4	131	2.23	97.77
" " " ...	8	2	90	35	14	41	155	7	39	109	42	205	17.00	83.00
" " " ...	7	3	92	35	18	39	145	10	56	79	45	192	19.98	81.02
" " " ...	10	4	181	98	22	61	209	14	64	131	112	278	28.71	71.29

This table shows the smallness of the crop and that the trees sprayed oftenest gave the largest per cent of sound fruit, while the untreated trees produced least. Again it is seen that among the wormy apples in every case—both of windfalls and apples picked from the trees—the smaller per cent were stung through the claxy. Furthermore, it was observed that an exceedingly large amount of the windfalls were stung. The trees, of both varieties, sprayed four times, were the only ones that gave over 50 per cent of sound fruit of the apples picked. The fruit on these trees was picked on the 5th of October.

Notes Made in Mr. Theo. Rouault's Orchard

This orchard is about three fourths of a mile northwest of the Station orchard, and the trees are large and vigorous. A full crop was produced by the trees this season. No spraying was done, or in any way was the codling moth checked in its work. To get an idea in regard to what the pest was doing in an unsprayed orchard, a few observations were made on October 4th. An average Ben Davis tree was selected in about the middle of the orchard. The ground was covered with apples, showing that a large part of the crop produced by the tree had fallen. Unfortunately, the windfalls were not counted and examined on account of so many of the first ones that fell, being decayed, so one could not tell whether they were stung or not. There were 629 fine specimens picked from the tree. Of this number 319, slightly over 50 per cent, were sound, 150 were stung on the calyx, and 160 on the side. These facts substantiate the observations at the Station and at Mr. Burke's orchard that, on unsprayed trees of winter apples, not much over half of the fruit on the tree at harvesting time is sound, and that the smaller per cent of the wormy apples are stung on the calyx.

Summary

1. The codling moth is the most serious drawback to the profitable growing of apples in New Mexico, and unless it is checked in its work the apple industry is likely to suffer.

2. Spraying in this region is beneficial, and will reduce the percentage of stung apples very materially. Better results can be obtained by frequent and continuous spraying.

3. The two early sprayings recommended by eastern experimenters are not very satisfactory here, and they can be given after the blossoms fall and the calyx cups have closed.

4. On the whole the arsenite of soda is the most satisfactory. A barrel of this mixture is cheaper than a barrel of Paris green solution, but costs more than a barrel of the mixture of arsenite of lime.

5. The early apples are quite free from worms, as they are injured principally by the first brood of worms, which is not very bad. A large per cent of the late apples, which are injured by the late broods of the codling moth, are very wormy.

6. During "off years" or on trees of very small crops, spraying does only a little good.

7. Practically 50 per cent of the fruit picked from unsprayed trees, with a good crop, is injured by the codling moth.

8. As a rule, spraying tends to reduce the number of windfalls. Over 90 per cent of the windfalls from unsprayed trees are wormy.

9. The smaller per cent of the wormy apples—among winter as well as early varieties—are stung through the calyx.

Acknowledgments

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AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

ALKALI

BY

JOHN D. TINSLEY

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The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others as far as the editions printed will allow.

INTRODUCTION

The alkali problem is a matter of more or less interest and importance in nearly all irrigated districts of the arid region, and is an exceedingly important question in certain parts of New Mexico.

That there is need for information on the subject is shown by the following illustrations. The writer has seen places in the territory where hundreds of dollars (in labor and seed) were wasted in trying to grow crops on land that contained enough alkali to prevent the germination of seed. He has also seen land, where the water table was within less than two feet of the surface, flooded for days in the vain endeavor to wash off the salts.

The object of this bulletin is to present information on the subject of alkali, its composition, origin and similar points, that will enable the reader to apply the methods suggested for the prevention of the accumulation of alkali and its removal when it has already accumulated in injurious amounts.

The matter in this bulletin is drawn from all the literature on the subject available to the writer, a list of which will be found at the end of the bulletin, and from investigations by the writer, in the field and laboratory extending through several years.

Special attention is given, in the following pages, to the points most applicable to the conditions in the Pecos valley as the chemical department of this station has already published several bulletins relating to alkali in the Rio Grande and Animas valleys.

This bulletin is to be followed, at an early date, by another, describing an experiment on drainage at Roswell, N. M., and dealing more in detail with the subject of improving alkali lands.

For a detailed discussion of the soil and alkali conditions in the Pecos valley the reader is referred to the article entitled "A Soil Survey in the Pecos Valley, New Mexico" by Thos.

H. Means and Frank D. Gardner, in Report No. 64 U. S. Dept. of Agriculture, Bureau of Soils. This may be obtained upon application to the New Mexico delegate in congress.

The department of soils of this experiment station is studying the alkali and soil conditions of the territory as rapidly as circumstances permit and is always willing to render assistance in these matters to the people of the territory.

ALKALI

Definitions

An "alkali soil" is one containing such an accumulation of soluble salts as to render it unfit to support ordinary vegetation.

These soluble salts, which when in excess are so injurious to vegetation, are present in some amount in all soils and when their quantity is small they, instead of being harmful, are sources of fertility.

When sodium carbonate is present, in appreciable amounts, among the soluble salts they are called "black alkali."

If sodium carbonate is absent, no matter what the composition of the salts present may be, they are called "white alkali."

In New Mexico many spots containing only white alkali are quite dark in color, and these are often called black alkali spots on the supposition that they contain true "black alkali."

Black Alkali

Sodium carbonate is the essential constituent of "black alkali." It is known by the common names of sal soda and washing soda. It is a true alkali in the chemical sense of the term, and one of its most characteristic properties is that of corroding animal and vegetable matter. In the soil, though usually present in comparatively small amounts, it shows its corroding power not only on plants but also by acting on the vegetable matter in the soil, turning it black and making it readily soluble. This black material accumulates on the surface with the salts. This characteristic blackening gave rise to the name "black alkali."

While it is often true that the blackening of the soil indicates the presence of sodium carbonate, it is not always so, for many spots quite dark or nearly black in color, are found which contain no sodium carbonate, but do contain a large quantity of white alkali. On the other hand soils containing very little vegetable matter may contain considerable quantities of sodium carbonate and yet show no darkening in color.

The Bureau of Soils * has adopted Hilgard's value of 0.1 of 1 per cent of sodium carbonate in the soil as the maximum amount that crops will stand; and have assumed .05 of 1 per cent as the danger limit, i. e. when there is .05 of 1 per cent of sodium carbonate in a soil most crops will be liable to suffer, especially since this amount is very liable to be increased by the evaporation of water from the surface of the soil.

In a recent bulletin Hilgard† has shown that the amount of sodium carbonate necessary to injure or kill plants depends —on the kind of plant, some plants being much more resistant than others,—the nature and amount of the other salts associated with the sodium carbonate, common salt being more injurious than sodium sulphate (Glauber's Salts),—and on the nature of the soil, plants withstanding a less amount in heavy soils than in light.

A careful search has thus far failed to show the presence of sodium carbonate in injurious amounts in the vicinity of Roswell, and Carlsbad, N. M., or Barstow, Texas, and it is not likely to be found elsewhere in the Pecos valley, the reason for its absence will be explained later.

It may be of interest to note here that the writer has found traces of sodium carbonate in several alkali crusts from Roswell, N. M., and Barstow, Texas. Examination of a sample of alkali on grass, above the surface of the ground, from the experiment station farm at Roswell showed .25 per cent of soluble carbonates.

For a further discussion of black alkali in New Mexico see N. M. Expt. Station Bulletin 22.

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* U. S. D. A. Bureau of Soils Rept. No. 64, p. 35.

† California Expt. Station Bul. No. 133.

White Alkali

Composition. White alkali is not an alkali at all in the chemical sense of the term, but consists of a mixture of a number of different chemical compounds in varying proportions. Two samples taken only short distances apart will seldom show the same composition. The principal chemical compounds found in white alkali are sodium chloride (common table salt), sodium sulphate (Glauber's salt), magnesium sulphate (Epsom salts), calcium sulphate (gypsum), and sometimes magnesium and calcium chlorides. In addition to those already mentioned, there are a number of other compounds in greater or less amounts, especially salts of potassium. In some localities the alkali consists principally of sulphates, while in others it is mainly chlorides. This difference in composition, however, makes but little difference in the effects on plant life, so far as the writer has been able to observe them in the field.

In the following pages, where the term "alkali" is used, it will refer to the white variety.

Composition of "Alkali" in the Pecos Valley

The alkali has the general composition stated above. A recent examination of a number of samples of crusts and soils collected in the vicinity of Roswell, N. M., and of Barstow, Tex., shows that at Roswell sulphates predominate over chlorides, while at Barstow, the chlorides seem to exceed the sulphates. These samples, however, do not include any from the Pecos flats, near Roswell, and a hasty examination of these flats indicates that the chlorides probably equal the sulphates, if they do not exceed them there. The analyses of samples from the vicinity of Carlsbad, N. M. (Bureau of Soils, Rept. 64) show an excess of sulphates over chlorides in most cases.

Recent work, by Cameron and others connected with the U. S. D. A. Bureau of Soils, indicates that account should also be taken of the bicarbonates, the most injurious of which is bicarbonate of sodium (common baking soda); this usually occurs with sodium carbonate (black alkali) but may, under certain conditions, occur in the absence of the carbonate.

The Roswell and Barstow samples show amounts of bicarbonates varying from .15 to 1.25 per cent, but whether this is sodium bicarbonate or other bicarbonates (those of lime or magnesia) the writer is not at present prepared to say. It may be safely stated that injurious amounts of sodium bicarbonate rarely, if ever, exist in the Pecos valley.

A good discussion of the Pecos valley alkali is given by Means and Gardner in Report No. 64, U. S. D. A. Bureau of Soils.

Reactions Between some of the Constituents of Alkali

The soils of the Pecos valley contain considerable amounts of calcium carbonate (lime-stone) and gypsum, besides the other salts, in fact large amounts compared with the soluble salts. Under certain conditions, changes may take place between the calcium carbonate, gypsum and the soluble salts.

Cameron* considers the characteristic change in the Pecos valley soils to be that between gypsum (calcium sulphate) and common salt (sodium chloride), in which are formed Glauber's salt (sodium sulphate) and calcium chloride. This explains the presence of the large proportion of sodium sulphate found in the soils. The absence of correspondingly large amounts of calcium chloride is explained by its ready solubility, which would allow it to be quickly leached out.

Another change which is likely to occur was pointed out by Hilgard and Weber,§ investigated further by Jaffa,† and discussed by Cameron,‡ this is the reaction between alkali sulphates and chlorides and calcium carbonate. Alkali sulphates and chlorides react with calcium carbonate in the presence of carbonic acid (carbon di-oxide) and moisture, forming alkali carbonates (or bicarbonates, and probably both) and gypsum.

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*Bulletin 17, Bureau of Soils, U. S. D. A.

§Reports of Examinations of Waters, Water Supply and Related Subjects—1886-1889. Part of Report of California Expt. Station for 1888—1889.

†Report California Expt. Station for 1890.

‡Report No. 64, U. S. Dept. Agriculture.

Cameron considers the carbonic acid an aid to the reaction, but does not deem it absolutely necessary. As an example of this reaction: Sodium sulphate and calcium carbonate, in a wet soil and in the presence of carbonic acid, will form sodium bicarbonate (baking soda) and gypsum. Carbonic acid is practically always present in the soil from the decomposition of vegetable matter and from that dissolved from the air by the soil moisture.

The sodium bicarbonate (baking soda) is very likely to change, in the soil, into sodium carbonate (black alkali). This reaction probably explains the formation of the bicarbonates and carbonates which are found in the Pecos valley soils, and were it not for another reaction we would expect to find considerable amounts of black alkali in the Pecos valley.

The following reaction explains the comparative absence of black alkali (sodium carbonate) in the Pecos valley. When sodium carbonate comes into contact with gypsum—especially if there is at least twice as much gypsum as sodium carbonate—in the presence of water or wet soil, they react with the formation of calcium carbonate and sodium sulphate. The calcium carbonate has no injurious action on plants, and the sodium sulphate is much less injurious than black alkali. From this we see that the large amount of gypsum in the Pecos valley soils serves to convert any considerable amount of black alkali formed into the less harmful sodium sulphate, and we would, therefore, not expect to find any large amounts of black alkali in these soils.

Recent experiments by the writer show that when the above reaction takes place, there is, at the same time, a formation of small amounts of bicarbonates, probably due to reaction between the sodium sulphate and calcium carbonate formed by the main reaction.

Loughridge,* in treating a sample of soil of high black alkali content with gypsum, in the laboratory, found that there remained .021 to .025 per cent of carbonates, and attributes this, as well as certain rises in amounts of sodium carbonate found at different periods, to the reaction between the carbonates of lime, or magnesia, and the alkaline sulphates in the presence of water and carbon di-oxide.

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*Report of California Expt. Station for 1895–'96; 1896–'97.

Hilgard long ago pointed out that this reaction between gypsum and sodium carbonate made possible the reclamation of black alkali lands by the addition of gypsum and then flooding, especially where the soils possessed sufficient natural drainage, or where artificial sub-drainage was provided. Numerous references, in the reports of the California Experiment Station, to experiments with this method, show that it has proved successful in field practice.

Kearney and Cameron,* in water culture experiments on the effects of salts on seedlings of lupine and alfalfa, did not find gypsum to overcome the effects of sodium carbonate to the extent that California field tests indicate that it should.

Origin of Soils and Alkali

Soils are derived from the breaking down of rocks by the various disintegrating agencies to which the rocks are exposed, such as frost, the dissolving power of water especially that containing carbonic acid gas, chemical action of the air and decomposing organic matter, and many other means.

In many places the gradations from soil to the unchanged rock from which it was derived may be found on digging downward from the surface. Such soils are said to be "in situ" or "in place" to distinguish them from those soils which have been carried by running water, moving ice, the wind, or other agents and deposited at a distance from the place where they originated. When so transported the materials are further decomposed and pulverized, and when carried by water they will usually be deposited in the order of their size and weight as the velocity of the water decreases, the larger and heavier being deposited first.

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* The subject of the reactions between the constituents of alkali is discussed at considerable length in Reports Nos. 64 and 71 of the U. S. Dept. of Agriculture and in Bulletin 17 of the Bureau of Soils, U. S. D. A.

When rocks are decomposed some of the substances formed are quite soluble in water while others are less soluble and some almost insoluble.

In cold and humid climates the decomposition of rocks takes place more rapidly than in the arid regions, and one might expect to find more salts in those soils were it not for the fact that the abundant rainfall soaks down through the soils, washes out the soluble material and carries it off through the streams to the ocean.

In the arid regions the rainfall has not been sufficient to wash out the soluble salts thoroughly, and the alkali which was washed out was not all carried off to the ocean.

Much of the rainfall does not find an outlet through the streams but accumulates in low places where it finally evaporates. Many of the streams finally either disappear or empty into lakes which have no outlet and as the water evaporates the salts remain.

Some of our New Mexico valleys show signs of having been old lake beds and some were possibly arms of the sea which were cut off and finally partially or wholly dried up. As these bodies of water dried up much of the soluble material contained in the water was carried into or deposited on the soil of the lake or sea bottom; so that the soil and alkali may be considered as having been deposited together.

The rains have since been continually dissolving these soluble materials and carrying them off until most of the alkali has been removed from the high lands, and also from the low lands where the drainage is sufficient.

The writer does not believe that recent decomposition of the rocks is sufficient to account for the total amount of soluble salts present in the soils of southern New Mexico. Most, if not all, of the soils of the plains and valleys of southern New Mexico show an abundance of water worn pebbles indicating quite an extensive action of water in times past, and also indicating that these soils have been worked over and over by moving water. This water worn material as well as the smaller mineral particles of the soil show but slight indications of disintegration, and the indications are that much of the fine material which gives the clayey characters to our soils is extremely finely ground mineral particles rather than true clay.

In regard to Pecos valley conditions Means and Gardner write as follows (Report No. 64 U. S. D. A. p. 54):

"In past geological ages arms of the ocean were sometimes cut off from the main ocean and the waters concentrated by evaporation until part or all of the burden of soluble matter was deposited. Beds formed in this way today, when elevated above the level of the sea and exposed to erosion, give rise to quantities of alkali. The red beds, forming the great plains north of Roswell, in the Pecos valley, and underlying the Staked Plains to the east, were deposited in this way, and it is reported that a bed of rock salt over 400 feet deep has been encountered in boring for an artesian well at Carlsbad, and all of the soils from this formation contain soluble matter. The beds of gypsum and salts deposited indicate that the ocean water was concentrated by evaporation. Included within this gypsum are small quantities of soluble salt.

Another source of alkali in the Pecos valley is from the decomposition of volcanic rocks. To the west of the Pecos great areas of apparently recent lava are found, and associated with the lava are alkali springs of varying degrees of concentration. Some of the deposits of gypsum in the Pecos valley can be accounted for only on the assumption that the gypsum is the result of the action of acid waters upon limestone.

Even though the lava flows were not associated with the alkali springs, the decomposition of the igneous rocks would give rise to the formation of alkali salts, and without doubt the igneous rocks west of Roswell are the source of parts of the alkali salts."

Soil Texture, Percolation and Capillarity

Texture. In order to understand the manner in which water rises through the soil, and is supplied at the surface, to replace that lost by evaporation, it is necessary to examine the structure of the soil. When a soil is examined under the microscope, it is found to consist of particles, or grains, of varying sizes and shapes. If the sample is a clay, very small particles will be found most abundant; while if it is a sand, larger particles will be found to predominate; and, according to the relative quantities of fine and coarse particles, soils are classified as clays, clay loams, loams, sandy loams and sands. Those composed mainly of fine particles, as clays and clay loams, are said to have fine, close, or heavy texture, while those composed mainly of larger particles, as sands and sandy loams, are called coarse, open in texture, or porous.

Percolation. It is a well known fact that soils of coarse texture allow water to pass downward through them readily; while fine grained soils, as clays, allow it to pass much more slowly. This is due to the fact that the spaces between the soil grains in coarse soils are comparatively large and the water meets with less resistance than in passing through the smaller spaces.

In fact, the movement of water in the spaces in clay soils takes place very slowly, and in many cases the principal movement of water in heavy soils takes place through the larger spaces of the soil, such as cracks and worm burrows. Some clay soils allow water to pass through them readily because of the numerous cracks. Such a soil is that of the Hondo bottoms, near Roswell.

This subject will be discussed further in a bulletin, to be published soon, on drainage as a means of improving alkali lands.

Capillarity. The capillary power of soils is shown by their ability to bring up moisture from below. This action of the soil is similar to the raising of oil by a lamp-wick. This property of a soil can readily be shown by filling a glass tube with dry soil and immersing the lower end in water. The water will rise through the soil, at first rapidly and then more slowly. The height to which the water will rise depends, principally, upon the size of the spaces in the soil, and therefore upon the size of the soil grains. Soils of fine texture raise water to a greater height than do those of a coarse texture, but the rise is more rapid in the sandy soils. From this we see that it is not safe to let the water table rise so near the surface in clay as in sandy soils.

Water containing much dissolved alkali will rise to a greater height in a soil than will water containing very little, but it evaporates more slowly from the soil surface.

Accumulation of Alkali

The principal sources from which we may expect an accumulation of alkali are two.

First.—From the accumulation and evaporation of water in low places. Under the present conditions in New Mexico, cultivation is principally confined to the bottom lands, or at least to those which lie low enough for water to be taken to them by canals. The land lying higher than this, as well as these soils, contains soluble salts, though often not in sufficient quantity to be injurious. When rain falls on this high land the water in passing over and through the soil dissolves some of the soluble salts. If this water accumulates on the surface in low places, forming ponds, and remains until the greater portion of it evaporates, the alkali held in solution is left. This process, continued for a long time will produce an alkali flat. If, however, the low land is porous and has sufficient under-drainage to prevent the formation of ponds, the water in passing through the soil will carry the salts with it, and the soil will be left in good condition.

In this connection may be mentioned the tendency of alkali to cause the soil particles to run together, and the soil to become almost water tight, so that there is very little drainage, which favors the formation of ponds.

Where high lands are under irrigation, as in the Pecos valley, the danger to the low lands from surface water is increased. In addition to the rainfall, the excess of water from over irrigation and the seepage from leaky ditches tends to flood the low lands.

Second.—By the accumulation of sufficient water in the soil to raise the water table high enough for capillarity to supply the water lost by evaporation at the surface. This is the most important cause of the accumulation of alkali in cultivated districts, and is well shown in many places in the Pecos valley.

The most favorable conditions for such an accumulation are a bed, or layer, of material, usually clayey in character, which allows water to pass through it very slowly, if at all, and a soil above this which does not have sufficient lateral drainage. The length of time required for the water table to be raised too high in such a soil will depend on several factors; among them the depth of the water tight stratum, the amount of water coming in, and the rate of natural drainage.

The source of water may be springs or the percolation of surface water, but in irrigated areas it is usually the seepage from leaky canals, or the excess of water used in irrigation.

When the water table has been raised, by whatever cause, to within a certain distance from the surface, capillarity begins to carry the water to the surface, where it is evaporated. The depth of the water table, from which capillarity will be able to cause trouble, will depend upon a number of conditions, and cannot be definitely stated, but on the Hondo bottoms it is about three feet.

Since all the water in soils contains some salts in solution, if surface evaporation, under the conditions described, should continue long enough, and there was little or no percolating water, the surface of the soil would eventally have its salt content materially increased. In the arid region, however, nearly all of the waters carry considerable amounts of dissolved salts. The soils also contain salts, especially those of the low lands. The water in rising through the soil dissolves some of the soil alkali, thereby increasing its salt content, so that when it reaches the surface it contains a comparatively large amount of salt. . The water evaporates at the surface, but the alkali is left, and, in the course of time, enough may accumulate to form a crust of fairly pure salts, or at any rate the salts are left in the first few inches of the soil.

To further impress the idea of accumulation of alkali, let us take the following example: Suppose an acre of land, with the water table within less than two feet of the surface, and that the amount of water evaporated from the surface in a year was enough to cover the acre to a depth of one foot, which the writer considers a low estimate for a bare soil. Suppose further that when it reached the surface, the water carried 100 parts of soluble matter in 100,000 parts of water, which is about the salt content of the best irrigating waters in the Roswell district. This would give 43,560 cubic feet of water on the acre, which would weigh about 2,720,000 pounds, and would leave on evaporation 2,720 pounds of salts, about one and one-half tons.

This would amount to an addition of .07 per cent of salts to the surface foot of that acre per year. If this were continued about seven years, and none of the salts were removed, the amount added would be about .5 per cent in the first foot of soil, which is more per foot than cultivated plants could usually withstand. Under actual conditions, it is probable that more than one and one-half tons of salt per acre per year is carried to the surface in many cases, but the rain washes a portion of them back and they are distributed to a greater depth than one foot.

Prevention of the Accumulation of Alkali

Much has been written on this subject, but it may all be reduced to two fundamental ideas, keep the water table below the point where capillarity can bring up large amounts of water, and, diminish surface evaporation to the very least possible amount.

The height of the water table should be carefully watched wherever there is a possibility of its being raised by seepage, and if it shows any decided tendency to rise steps should immediately be taken to prevent its reaching the danger point. This may be done by either open or covered drains of the necessary depth, the drains should be at least three feet deep, and they will be of very little value if less than two feet, placed in the wet land. The best method is to find out the direction from which the water comes and put in a deep open or covered drain on that side. The water table can only be controlled by drainage. Where it is impossible to control the water table, as in low lands with no available outlet for sufficient underdrainage, reliance must be placed almost entirely on controlling evaporation.

As previously stated the accumulation of alkali at and near the surface may be due to the excessive evaporation of irrigating water from a soil that in its virgin state contained comparatively little alkali, or that it may be due to the bringing up of the salts from lower layers of the soil by capillarity, the water applied being quite pure as in the case of rain, usually, however, the alkali comes from both the water and the soil.

In all these cases whatever tends to reduce evaporation, will therefore retard the accumulation of alkali. Among the means of reducing evaporation are, surface cultivation, mulching and keeping the surface covered with vegetation.

Surface Cultivation. One of the very best means of preventing evaporation on soils which will admit of it, and where other conditions allow its use, is a dust mulch. Unfortunately it is almost impossible to pulverize the surface of some heavy soils, such as the clays and clay loams of the Mesilla valley, fine enough to form an effective dust mulch. The dust mulch is especially adapted to orchards and cultivated crops, and after each irrigation or rain the surface soil should be thoroughly stirred.

The beneficial effects of surface cultivation were well shown in the young pear orchard of Mr. Parker Earle, near Roswell, N. M., in the Hondo bottom, when examined by the writer on August 13, 1901. The depth of the water table at one spot was 21 inches and in another about 200 yards further north it was 30 inches. In spite of this nearness of the standing water to the surface there was no sign of alkali crust, and the upper portion of the soil was not unfavorably wet. The surface foot at each point contained .4 per cent of salts. Virgin soil near by covered with salt grass and having the water table at about the same depth, shows surface crust in many places and seldom contains less than 1 per cent of alkali in the surface foot.

Mulching. The use of manure, straw and similar materials for covering the soil to lessen evaporation can not be practiced on a very extensive scale, yet it may in certain cases be used with advantage. It is especially applicable in young orchards, where the mulch can be spread around the trees and thus diminish evaporation. This method might also be used to some extent in gardens.

Vegetation. The growth of vegetation by shading the ground has a marked effect in decreasing surface evaporation. The more perfectly the ground is covered by the plants the better the protection. The deeper rooted plants are also better than those whose roots feed nearer the surface.

While it is true that plants evaporate large quantities of water from their surfaces, this water is taken in by their roots which are scattered through a considerable mass af soil. Hilgard* says: "Such accumulation of alkali in and around the roots (of alfalfa), as can occur under such circumstances, is too much diluted to hurt the plant." When the concentration is due to evaporation from plants the salts are distributed through a greater quantity of soil than when the evaporation is from the soil surface.

The salt grasses (*Sporobolus airoides* Torr. and *Distichlis spicata* (L). Greene) are of great benefit in alkali districts, not only in adding to the appearance of the country and in furnishing considerable pasture, but are also exceedingly important in lessening evaporation and thereby checking the surface accumulation of alkali. Land well covered by salt grass seldom shows as much crust as does bare soil.

Alfalfa is a valuable crop, as has been pointed out by Hilgard and others, for decreasing soil evaporation, especially so, because it sends its roots so deeply into the soil and draws its moisture from such a large quantity of soil.

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*California Exp. Station Report for 1880.

The distinction between preventing the accumulation of salts either in the soil or at the surface and the actual removal of alkali from the soil must be kept clearly in mind. In many cases if the total quantity of alkali in the first four feet of the soil was distributed uniformly, through all this soil, the amount would not be injurious. In fact it is sometimes possible by deep cultivation to mix the first twelve to eighteen inches of the soil and so dilute the alkali that crops may be grown.

But in this case great care must be taken to prevent the rise of the alkali to the surface during the growing season, as the alkali has been only diluted and not removed. It should also be remembered that the growing of crops on alkali soils removes some of the alkali provided the crops are removed from the soils.

Relations of Manure to Alkali

The writer is often asked if manure is a corrective for alkali. There seems to be no possible chemical reaction by which manure can change the composition of alkali and render the salts less injurious, but its use often shows a marked benefit. This beneficial action may be due to two causes:

First.—It tends to loosen the surface, acting as a mulch, and thus lessens evaporation and the consequent accumulation of alkali at the surface.

Second.—It may act as a stimulant, especially to young plants, and enable them, by their greater vigor, to resist the action of the alkali.

That young plants are more susceptible to the effects of alkali than older ones, is a matter of common observation. This is often well shown where a piece of land containing considerable alkali is seeded to alfalfa. There may be practically no stand, and yet a few scattered plants manage to survive and often make good growth.

Older canteloupe vines also seem to be quite resistant to alkali, and if the plants can be started, they will often thrive in the presence of an amount of alkali that will kill the seedlings.

A good illustration of this was observed by the writer in the garden of Mr. Edward Hart, near Roswell, N. M , in August, 1900. This garden is situated on the higher land east of the town. the soil being Roswell sandy loam. There was a streak of alkali soil, running north to south, through the garden, on one portion of which canteloupe seed had been planted five times, and there were only a few scattered, sickly vines. Tests showed the first foot to contain .8 per cent, the second foot .6 per cent and the third foot .8 per cent of salts. On another portion of this streak there had been a corral the previous winter, and the land had been quite well manured.

This manure was, of course, plowed in when the land was broken up in the spring. On this portion there was a fine growth of canteloupe vines that were bearing well. Tests among these vines showed almost identical amounts of salts as the unmanured portion. The writer attributes this difference in the growth of the plants to the action of the manure, which probably consisted mainly in checking the surface accumulation of alkali, and thereby giving the plants a chance to get their roots well started.

In this connection it is interesting to note that, when visited again in August, 1901, this streak had nearly disappeared. The amount of salts in the surface foot had decreased to less than .25 per cent, and in the third foot to less than .2 per cent. During the previous winter, Mr. Hart had put about 320 two-horse loads of manure on this piece of about three acres. The soil was now in fine mechanical condition and the crops were very good.

This marked decrease in the amount of salts is most probably to be attributed to the leaching action of the irrigating water and rains—this soil being rather loose in texture, with fair natural under-drainage, allows water to pass through it quite readily—and to the mulching action of the manure, by which evaporation was materially decreased, so that the salts washed down were not brought back. This example shows how easily some rather bad alkali land may be reclaimed.

Removal of Alkali from the Soil

Three methods have been suggested for the removal of alkali from the soil: Removing the surface soil, growing of alkali resistant plants, and leaching combined with underdrainage.

Removing the surface soil. Where there is a heavy accumulation of alkali at the surface and much less below, crops may sometimes be grown by removing the surface with a scraper, then plowing deeply and keeping a good dust mulch throughout the growing season. This method, however, scarcely admits of extensive application.

Growing resistant plants. Soils containing only a moderate excess of alkali above the amount injurious to ordinary crops may be improved by growing alkali resistant crops—such as sorghums and other giant grasses, beets, carrots and, when conditions permit, alfalfa. Cotton, also, seems about as resistant as alfalfa, and perhaps varieties may be found which are more resistant. The Bureau of Plant Industry of the U. S. Dept. of Agriculture contemplates experiments on alkali resistant cottons. It is, of course, necessary that the crops be removed from the land.

This method, while better than the preceding, is slow, and scarcely to be recommended generally for the Pecos valley conditions, since here the alkali is usually accompanied by ground water too near the surface. It would, however, prove beneficial where the water table is at a considerable distance below the surface.

Leaching and under-draining. This is the only method which can be highly recommended for the removal of alkali. It consists in repeatedly flooding the land, which can be done in winter when the supply of water is abundant, and removing the excess of water by a system of drains, which may be either open or covered. Tile or other covered drains, while more expensive in their first cost, will probably prove to be the cheapest in the end, because of the expense of keeping the open drains clean and the amount of land which they take up.

This method is especially applicable to the Pecos valley, because so much of the land already needs draining, and in most of the area it is perfectly feasible. This subject will be discussed in detail in a subsequent bulletin.

Amount of Alkali Injurious

Black alkali. The amount of black alkali that crops can withstand, as previously stated, is about .10 per cent. Goss* states that in the Animas Valley, N. M., .23 per cent of sodium carbonate in the surface soil was sufficient to entirely prevent the germination of the seeds of ordinary farm crops. There are so many factors entering into this matter of resistance that it is almost impossible to make a statement applicable to all localities, so that the limits have to be worked out for each district. The soil, climatic conditions, and especially the amounts and composition of the other salts associated with the sodium carbonate, will largely determine the limiting amount. There are comparatively few localities in New Mexico, at present known to the writer, where black alkali has to be taken into consideration.

White alkali. Hilgard and Loughridge, in the various publications of the California Experiment Station,§ have stated the amounts of alkali tolerated by various crops under California conditions. It is to be noted, however, that nearly all their samples of alkali contained more or less sodium carbonate. and therefore their limits cannot be applied strictly to alkali containing no sodium carbonate. They have also found that common salt (sodium chloride) is more injurious than Glauber's salt (sodium sulphate). Buffum† also considers sodium chloride the more injurious.

Slosson and Buffum‡ state that barley, rye or alfalfa will grow in soil containing one per cent of alkali (mainly sulphates of sodium and magnesium) in the surface two inches, provided the water table is two to three feet below the surface.

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*Bul. 22, New Mexico Expt. Station, p. 31.

§Especially Bul. 133, Calif. Expt. Station.

† Bul. 43, Wyoming Expt. Station.

‡ Bul. 39, Wyoming Expt. Station, p. 47.

Means and Gardner* state "that in the soils of the Roswell area, alfalfa was just able to grow when the amount of salts was .40 to .50 per cent, and that .50 per cent is taken as the maximum limit. Though plants are able to grow with this amount (.50 per cent) of salt in the soil, the growth is uncertain and light; in fact .25 per cent damages crop growth to a great extent. In the Roswell area, alfalfa was found sickly and dying with a little over .40 per cent of alkali in the soil, while in other stages of its growth isolated plants have been found growing in a soil containing more than .75 per cent of alkali. Young apple trees showed signs of distress with a little over .30 per cent, while sugar beets grew with something over .50 per cent." These quantities express the average per cent in the first three to five feet of soil.

Subsequent studies by the writer in the vicinity of Roswell confirm these results.

In a hasty examination of the Barstow, Texas, district, practically the limits stated above were observed for alfalfa and cotton.

What has been said in regard to climatic and other factors in relation to sodium carbonate limits is equally applicable to the white alkali limits, so that the limits have to be determined for each district by direct experiments made there.

SUMMARY OF CONDITIONS IN THE ROSWELL AND CARLSBAD, N. M., AND BARSTOW, TEXAS DISTRICTS

The following brief description of these districts is drawn from a study of the descriptions and maps of Report No. 64, of the U. S. Department of Agriculture and from personal observations in the field by the writer.

Roswell District

The soils are classed as Pecos sandy loam, Roswell sandy loam, Roswell loam and Hondo meadows.

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*Rept. 64, U. S. Dept. Agriculture, pp. 56 and 57.

The Pecos sandy loam comprises the highest lands, comparatively little of which is under irrigation. The most of that under irrigation lies along the Berendo river and its tributaries. Over nearly all of this area the water table is at a depth of more than ten feet, and only in isolated spots does the salt content amount to more than .50 per cent. This soil is especially well adapted to fruit trees, though other crops also do well on it.

Roswell sandy loam takes in the greater portion of the remainder of the high land, and most of the alfalfa and stock farms lie within this area. The water table is at a depth of from three to ten feet under the most of it, but in some places it rises to within less than three feet of the surface. It may be stated in a general way that where the water table is three feet or less, the alkali content of the soil is .50 per cent or more, while that portion having the water table at a depth of more than three feet, shows a comparatively small amount of salts.

Roswell loam. This area lies within that of the Roswell sandy loam, and under a considerable portion of it the water table is less than three feet from the surface, and, as would be expected, this portion has .50 per cent or more alkali in the soil.

Section 36 lies within this area, and though it is mostly virgin soil, the salt content of the greater part of it is high, although the water table is generally at a depth of three feet or more. This is probably due to the seepage from a canal running through it, and also to seepage from the adjacent cultivated land.

Hondo meadows. This type takes in the bottom lands along the streams, the largest body of which lies along the Hondo river. The soil is a clay loam running into a clay beneath. Though heavy in texture, it allows water to pass through it readily, due to the numerous crevices and the fact that the soil grains are cemented into larger grains. The water table here varies from water standing on the surface in places, to a depth of six feet on the banks of the stream. The most of it has the water table at a depth of two to three feet. Practically all of this type is quite salty, but it admits of easy reclamation by under-drainage into the Hondo. It can be more cheaply drained than any other land in the Roswell district, and when freed from the excess of water and salt will compare favorably in fertility with any land in the United States. It should probably be regarded as especially adapted to alfalfa, but, as shown by experience, it will produce any crop grown in the Pecos valley.

From what has been said it will be readily seen that the accumulation of alkali in the Roswell district is very closely connected with, and really dependent upon, the accumulation of water, which has raised the water table to the point where capillarity is bringing up a large amount, which is being evaporated, and the salts left in the soil. When this excess of water is removed, the alkali will cease to accumulate and soon be washed out of the soil.

Carlsbad District

The area under discussion comprises the land lying between the southern canal and the Pecos river, from about one mile north of Carlsbad to a mile south of Malaga station.

The soils are classed as Pecos sands, Pecos sandy loam, Pecos conglomerate and Pecos gypsum.

Pecos sands. This comprises a number of isolated areas lying adjacent to the river. The water table is generally three feet or less, and the salt content is quite low. In some places, especially in the vicinity of Carlsbad, this soil is under cultivation and, where deep enough, produces good crops. It is especially adapted to vegetables and small fruits.

Pecos sandy loam. This is the principal soil type of the district, and under most of it the depth of the water table is ten feet or more, but in some places it approaches the surface. The rise of the water table is due to seepage from the canal and laterals. Here again the areas having the water table at three feet or less show .50 per cent or more of alkali.

Pecos conglomerate. This type comprises the gravelly and rock, areas found in the Pecos sandy loam, which it underlies throughout the district. It is difficult to cultivate, because of its gravelly nature, and allows water to pass through it quite readily. It is, for the most part, fairly free from alkali and has the water table well down.

Pecos gypsum. This also occurs in isolated areas in the Pecos sandy loam, but the principal area is between Otis and Florence and south of Florence. This soil is composed principally of gypsum, which, though itself not injurious to plants, gives to the soil, when present in such large amounts, very undesirable qualities. These qualities are great porosity and high capillarity. Such soils allow water to pass through them very freely, and ditches through them lose their water so rapidly that it is almost impossible to make either irrigation or drainage ditches in them.

The great capillary power enables them to bring up water from considerable depths, and their surface is usually high in alkali from the evaporation taking place there.

Until land becomes much more valuable, it is unwise to try to cultivate either the conglomerate or the gypsum soils.

The Carlsbad district does not seem to be as well adapted, generally, to alfalfa as the Roswell district, though a considerable amount is raised there. Fruits and vegetables do quite well in the best soils, and the giant grasses—sorghums and the like—do exceptionally well, and find a ready local market for lamb and cattle feeding.

The high salt content of the Pecos river water, especially in some seasons, makes it necessary to use it with care if these soils are to be brought up to their highest possibilities.

The low areas will have to be underdrained and steps taken to prevent the owners of high lands from using such an excess of water as to injure the low lands by seepage. It will also be necessary to guard against seepage from the canal and laterals. Above all things it is necessary to keep down surface evaporation from the soil, which should be done by thorough surface cultivation, and land when not under cultivation should be sown to some crop which will cover the surface and thus lessen evaporation.

Barstow District

The area under discussion comprises the land in the vicinity of Barstow irrigated by a canal taken from the Pecos river on the west side.

Five types of soil are found in this district—Pecos sands, Pecos sandy loam, a clay loam underlaid by clay, similar to the Hondo meadows at Roswell, Pecos conglomerate and Pecos gypsum.

Pecos sands. This type is not so abundant as the sandy loam or clay loam, and it occurs in isolated areas. The water table is, as a rule, well down, and the soil is quite free from alkali. It grows good cotton and giant grasses, and would probably grow good peach trees and canteloupes. This soil is underlaid by gypsum, at least in some places, but the low capillarity of the sand prevents the accumulation of alkali.

Pecos sandy loam. The most of the land under cultivation is of this type. It makes up the higher ground. Some of it in the virgin state is rather salty; the most of that under cultivation is in good condition, but some of it is salty. Taken as a whole, however, the land under cultivation contains less than .50 per cent of alkali. It seems to be generally underlaid by the conglomerate at varying depths, and in a few places is underlaid by gypsum, in which cases it is usually salty, especially where the gypsum comes to within eighteen inches of the surface. Cotton and canteloupes grow very well on this soil; giant grasses and alfalfa fairly well. Only one orchard was noted on it, and in that a number of the trees were suffering from the effects of alkali, because it is located on one of the spots where the gypsum approaches to within about two feet of the surface. Many of the trees, however, are quite healthy, and the fruit, mainly peaches, is of very good quality.

Hondo meadows. The land of this type lies nearer to the Pecos river than do the types described above. The water table is too near the surface under most of it, and in some cases approaches quite close to the surface. Even where the water table is at a depth of four feet, the land is very salty. The texture being heavy, this soil brings up water more slowly than loam, but brings it up from a greater depth. The writer saw none of it in successful cultivation, and it will be somewhat difficult to reclaim, as the drainage ditches will have to be quite deep, and the leaching will be slower than in the lighter soils.

Pecos conglomerate. This underlies a considerable portion of the district—its boundaries were not determined—cropping out at the highest points and forming a gravelly soil, which generally lies too high to be irrigated.

Pecos gypsum. This underlies some portions of the district at variable depths, occasionally coming close enough to the surface to give trouble. There is no use in trying to do anything with the spots where it is at or very near the surface.

The small amounts of alkali found in some of the cultivated land, and the condition of the crops (cotton, alfalfa, giant grasses, fruit, and canteloupes) proves that a considerable portion of this area can be profitably cultivated, and the cultivated area can be materially increased by an efficient system of underdrainage. It further proves that the water of the Pecos river, though containing salts far in excess of the amount usually considered safe for an irrigating water, will not cause an injurious accumulation of salts in soils of light texture when there is sufficient underdrainage and evaporation is reduced to a minimum.

A LIST OF THE ARTICLES, ACCESSIBLE TO THE WRITER, BEARING ON THE SUBJECT OF ALKALI AND ALKALI SOILS

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Report for 1876 and 1877, pp. 43–49. Hilgard, E. W. Alkali Soils.

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Report for 1880, pp. 12–22. Hilgard, E. W. Alkali Soils.

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Report for 1888 and 1889, p. 139. Hilgard, E. W. Alkali, alkali soils, their value and reclamation, and pp. 140–144. Hilgard, E. W. The rise of alkali in the San Joaquin valley (reprint of Bul. 83).

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BULLETIN NO. 43

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New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

DRAINAGE AND FLOODING
FOR THE
REMOVAL OF ALKALI

BY

JOHN D. TINSLEY

SANTA FE, N. M.:
NEW MEXICAN PRINTING COMPANY.
1902.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others as far as the editions printed will allow.

INTRODUCTION

There is a considerable amount of land in the vicinity of Roswell and elsewhere in the Pecos valley, the productive value of which is greatly decreased from having the water table too close to the surface, and a consequent accumulation of alkali in the soil.

Nearly all writers on the improvement and reclamation of alkali lands have advocated sub-drainage in connection with flooding as the best method of removing white alkali from the soil. So far, however, as the writer can find in the literature available to him comparatively few carefully conducted experiments have been made on the subject.

At the suggestion of the writer, the council of the New Mexico Experiment Station decided to try such an experiment on a piece of Hondo bottom land, as an object lesson in underdraining with tile drains combined with flooding for the improvement of alkali land.

The experiment was to be conducted by the departments of Soils and Agriculture. The tile was ordered during the winter of 1899.

Prof. Charles A. Keffer, then agriculturist of the station, having resigned in December, 1899, the work was placed in the charge of the Department of Soils. The writer made a detailed study of the water and alkali conditions of the 20 acres in March, 1900, and the drains were put in during April, the work being completed by May 1st, 1900. In the summer and autumn of 1900 the flat was given a number of heavy irrigations. It was intended to break up the land adjacent to the drains in the spring of 1901 and plant it in narrow plats, running north and south, to various crops, continue the flooding and study the effects of the varying depths of water table and the alkali on the growth of these crops. It was also desired at the same time to study the necessary depths, distances apart and cost of the drains, and they were arranged with this end in view.

In March, 1901, by an act of the Territorial Legislature the farm was returned to its original owners and the experiment was therefore practically abandoned. The results obtained from the work already done are, we think, of sufficient interest and value to warrant publication.

The drainage system was located by Mr. W. M. Reed, C. E., of Roswell. He also supervised the ditching, laying of tiles and filling, which were done by local men under contract.

Location

The land selected for this experiment is a part of the Hondo bottom, embracing about 20 acres on the S. W. ¼ of Section 34, Township 10 south, Range 24 east, about one mile east of the center of the town of Roswell, N. M. It extends from the Hondo river southward to the foot of the slope which forms the south boundary of the river bottom. The surface of the land rises from the bottoms rather abruptly at first for about 300 feet, and then more gradually off toward the south and southwest.

The line for the central drain was selected at the narrowest part of the bottom land, the width here being about 600 feet. On this line there is a fall toward the slope of about one foot in the first 100 feet from the river and of about half a foot in the remaining 500 feet. There is also a slight fall toward the east. In addition to the general slope to the south and east there are a few well-marked depressions in the surface.

The Pierce, Cunningham and Ballard irrigating canal is situated about midway on the abrupt portion of the slope, at this point about 150 feet from the end of the central drain. See Plate 2. The soil of this slope contains a large amount of gypsum, is somewhat gravelly, and allows water to passs through it quite readily, so that the seepage from the canal is large.

About a quarter of a mile to the south, and on higher ground, there is another canal, running from west to east, through the adjacent 40 acres. The soil through which this canal runs is Roswell loam,* underlaid by gravelly material derived from limestone conglomerate, which extends down to the bottom land. The nature of the soil makes it probable that this canal also loses considerable water which finds its way down to the flat.

Native Vegetation

The greater portion of the flat was covered with bunch grass, *Sporobolus airoides*, Torr. (called salt grass in this locality), in which there were some bare spots. The wettest portions were covered with true salt grass, *Distichlis spicata* (L) Greene, and where water stood on the surface, in the depressions, with Tule. The most important of the plants going under the name of tule in this locality are *Phragmites Phragmites* (L) Karst, called carrizo; *Typha latifolia* L, cat-tail; and *Scirpus lacustris* L, bulrush.†

Soil Texture

On the slope, from the ditch to the flat, the surface foot is mainly a sandy loam, and the second foot is a loam. Below two feet the soil is lighter in texture and contains a large proportion of gypsum with some gravel.

The soil of the bottom land is the "Hondo meadows" type of the Bureau of Soils, and consists principally of the sediment which has been deposited by the Hondo in times of flood.

The texture of the first foot varies from a very heavy clay loam on the south side to a light loam on the north side, next the river. The second and third feet vary from clay on the south to clay loam on the north side. Although the most of this soil is quite heavy in texture, it appears much lighter when examined in the field.

Its true texture is brought out on attempting to mix it with water, when it is found to be quite difficult to make into mud, for it acts like a very pure clay. This difference between apparent and real texture is possibly due to a slight cementing of the soil particles into grains, as was found by Means and Gardner to be the case with the Pecos sandy loam of the high lands in this vicinity.

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*Report No. 64, Bureau of Soils, U. S. D. A.

†The above plants were identified for me by Prof. E. O. Wooten, Station Botanist.

When wet lumps of the deeper layers of the soil were thrown out, in ditching, and allowed to dry, instead of baking very hard, as does the heavy soil of the Rio Grande valley, they soon crumbled into soil of splendid tilth. The breaking down reminds one of the slaking of lime. A practical application of these observations lies in the fact that if such a soil is cultivated when in proper moisture condition it is easily gotten into good tilth, but when worked too wet it will puddle and becomes very heavy and difficult to handle.

This soil allows water to pass through it much more freely than its texture would lead one to expect. While the ditches were being dug, the soil was observed to be full of seams and cracks, through which the water moved quite freely. This condition, while it allows the land to be quite readily seeped full of water, and as readily drained, makes the washing out of the salts much more difficult, since the water readily follows these crevices instead of passing between the soil grains and taking with it the salts dissolved in the moisture surrounding the grains.

Water Table

By water table is meant the surface of the sheet of water in the soil. Underground water may occur either in veins or in a sheet; in the latter case the depth from the surface of the ground to the surface of this water sheet varies very much in different localities. In the arid region wherever the water table lies near enough to the surface for capillarity to bring up the water freely to the surface of the ground there is usually an accumulation of alkali.

On the piece of land in which the drains were placed the depressions near the foot of the slope contained standing water.

In studying the water table four lines of borings, marked X on plate 2, were made on the east and three lines on the west side of the center of the plat. These borings were made with a two-inch soil auger and the depth to standing water in the holes was measured.

TABLE I

Line of borings 15 feet east from the center of the plat				
Distance north from the south boundary in feet	Depth to water in inches	Alkali in soil		
		Per cent in first foot	Per cent in second foot	Per cent in third foot
25	0	.35		......
90	2	.40	.40	......
120	4	.35	.40	......
150	6	.40	.35	......
180	18	.50	.40	......
210	12	2.30	.50	......
240	12	2.10	.50	......
275	12	3.00	.60	......
310	21	2.80	2.40	......
350	30	2.50	2.20	1.70
420	44	.55	1.90	.80
610	80			

Line of borings 50 feet east from the center of the plat				
Distance north from the south boundary in feet	Depth to water in inches	Alkali in soil		
		Per cent in first foot	Per cent in second foot	Per cent in third foot
0	0	.25	.15	......
41	0	.40	.25	......
51	0	.40	.35	......
74	0	.40	.45	......
84	0	.50	.40	......
102	0	.55	.50	......
112	3	.55	.50	......
131	4	.40	.35	......
141	6	.45	.35	......
161	6	.50	.35	......
171	6	.50	.40	......
192	9	1.85	.85	......
202	9	.70	.45	......
222	12	1.20	.60	......
232	12	.80	.45	......
252	12	2.50	.95	......
267	12	2.10	.55	......
295	18	2.30	1.50	......
308	18	3.00	2.10	......
334	24	4.00	2.50	......
348	24	2.40	1.10	2.20
391	30	.80	1.45	.65
420	33	.50	1.65	.65
443	36	.50	1.20	.65
507	52	.55	1.00	1.30
565	66	2.00	2.50	2.30
606	75	.25	.95	1.65

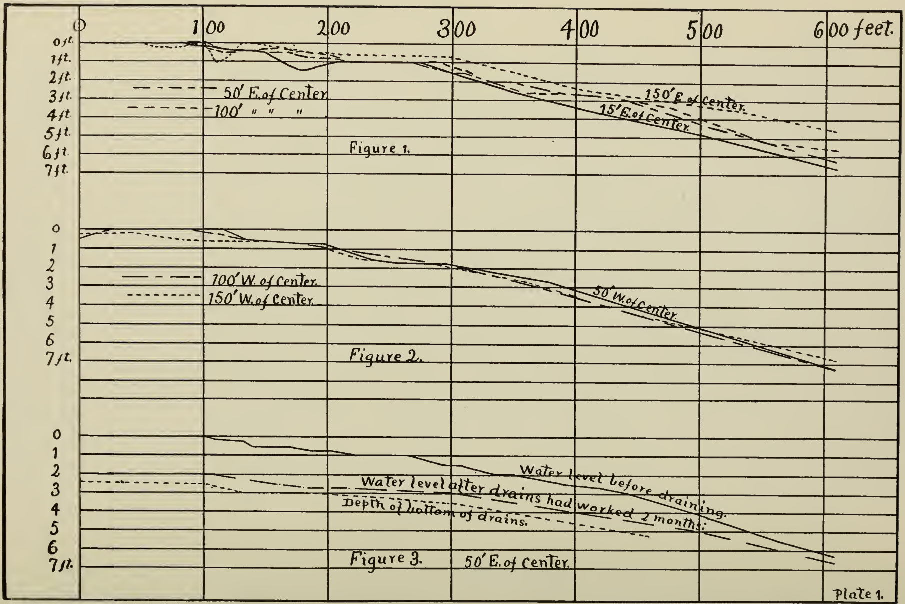
0
100
200
300
400
500
600 feet.
0 ft.
1 ft.
2 ft.
3 ft.
4 ft.
5 ft.
6 ft.
7 ft.
50′ E. of Center
100′ " " "
150′ E. of Center.
15′ E. of Center.
Figure 1.
0
1
2
3
4
5
6
7 ft.
100′ W. of Center.
150′ W. of Center.
50′ W. of Center.
Figure 2.
0
1
2
3
4
5
6
7 ft.
Water level before draining.
Water level after drains had worked 2 months.
Depth of bottom of drains.
Figure 3.
50′ E. of Center.
Plate 1.

Plate 1.

TABLE I—Continued

Line of borings 100 feet east from the center of the plat					Line of borings 150 feet east from the center of the plat				
Distance north from the south boundary in feet	Depth to water in inches	Alkali in soil			Distance north from the south boundary in feet	Depth to water in inches	Alkali in soil		
		Per cent in first foot	Per cent in second foot	Per cent in third foot			Per cent in first foot	Per cent in second foot	Per cent in third foot
0	0	.30	.20	......	0	0	.35	.15	......
30	0	.35	.25	......	10	0	.40	.20	......
40	0	.35	.25	......	20	0	.20	.15	......
60	0	.50	.35	......	40	0	.35	.20	......
90	0	.40	.60	......	50	0	.50	.25	......
115	6	.30	.35	......	75	3	.35	.35	......
125	6	.35	.40	......	100	0	.35	.35	......
145	4	.35	.35	......	110	12	.45	.45	......
155	4	.45	.35	......	130	0	.35	.35	......
175	6	.30	.30	......	140	0	.35	.30	......
185	6	.35	.30	......	160	2	.35	.35	......
205	8	.35	.35	......	170	2	.35	.35	......
215	12	.40	.35	......	190	6	.35	.35	......
235	12	.75	.50	......	200	6	.35	.30	......
250	12	.85	.45	......	220	8	.60	.45	......
275	12	2.50	.55	......	225	9	.55	.45	......
290	12	2.20	.55	......	260	9	.40	.30	......
315	18	2.90	.60	......	275	9	.35	.35	......
330	24	2.00	.90	......	300	10	.55	.30	......
365	30	1.00	.60	.55	345	8	.90	.30	......
390	30	.50	.95	.50	355	20	1.10	.55	......
415	32	.95	.85	.50	380	24	2.40	1.00	......
475	39	1.10	1.40	.85	405	28	2.50	1.10	1.70
556	63	1.50	2.30	2.30	480	36	2.50	2.30	1.50
600	66	.35	1.90	2.30	530	42	.60	2.20	1.60
					607	54	.20	1.00	1.50

TABLE I—continued

Line of borings 50 feet west from the center of the plat

Distance north from the south boundary in feet	Depth to water in inches	Alkali in soil		
		Per cent in first foot	Per cent in second foot	Per cent in third foot
67	0	.35	.35	......
116	0	.40	.40	......
136	5	.40	.35	......
176	8	.75	.30	......
196	9	.85	.40	......
236	18	1.30	.45	......
255	21	1.90	.95	....
296	21	.90	.50	.60
316	24	1.45	.60	.35
381	33	.80	1.00	.50
482	57	2.30	2.40	2.30
573	78	.85	2.20	1.60

Line of borings 100 feet west from the center of the plat

Distance north from the south boundary in feet	Depth to water in inches	Alkali in soil		
		Per cent in first foot	Per cent in second foot	Per cent in third foot
115	3	.30	.30	......
175	9	.60	.45	......
235	15	1.40	.40	......
290	21	2.30	.60	.55
370	36	1.00	1.90	.90
520	69	.60	2.40	2.50

Line of borings 150 feet west from the center of the plat

Distance north from the south boundary in feet	Depth to water in inches	Alkali in soil		
		Per cent in first foot	Per cent in second foot	Per cent in third foot
25	2	2.50†	.40	......
45	2	.35	.35	.....
85	6	.35	.30	......
105	8	.30	.35	......
145	8	.55	.35	.....
165	9	2.60	.50	.....
195	12	.60	.40	......
225	18	2.30	.40	......
265	21	2.50	2.40	......
285	21	.65	.45	.40
360	33	1.60	1.90	.70
455	54	.35	1.40	2.10
555	72	.40	.90	.50

† Omitted from averages in Table 2.

The results are given in Table 1 and represented graphically in Plate 1, Figures 1 and 2. The irregularities in the lines in Plate 1 are due to inequalities in the surface of the ground. The line 15 feet east of center will be observed to have the greatest fall, that 150 feet east of center the least. On the west side the lines are much closer together, the one 150 feet west of center having the least fall. The results also show that for half the distance the water table was near enough to the surface to prevent the growth of ordinary crops, and that only the north 200 feet had it low enough to make cultivation practicable, even if there had been no alkali.

Drainage Effect of the Hondo

One of the most interesting points brought out in this study of the water table is the action of the Hondo channel on it. The channel here is about 8 feet deep, and usually there are only a few inches of water in it at this point, which is derived from its drainage action on the lands west of here, the source of the water being principally the two canals before mentioned. When floods, derived from rains along its course, come down, the channel is often full, and sometimes overflowing, for a few days.

We may regard this channel as an 8 foot drainage ditch. and study its action as such. The river winds very much in its course, and this portion of it is no exception. Plate 2 shows its course here. It bends to the north just west of the west boundary* of the drains, then turns toward the south, and the central drain empties at the sharpest part of this bend; it then turns sharply to the north again.

The north boundary marks the northern limits of the lines of borings, and the bends in the river cause these points to vary considerably in distance from the channel. These differences in distance show a marked effect on the water table, as is seen in Table 1 and Plate 1.

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*For convenience, we will call lines drawn parallel to the center drain through the ends of the east, and west lateral drains the east and west boundaries, and lines through the north and south ends of the main drain and perpendicular to it the north and south boundaries. The area included by these lines we will call the plat.

The lines of borings west of the center terminate nearer the river and with less difference in distance from it than do those on the east, consequently the water table, along the west lines, shows less difference in depth, and a greater average depth at the north boundary.

The lines on the east side vary very much in the distance between their termination and the river, due to the sharp bend of the latter toward the north. The water table along these lines is consequently seen to be quite variable in depth, the greatest depths being found along the line 15 feet east, which terminates on the river bank, and the least depths being along the line 150 feet east whose termination is nearly a quarter of a mile from the river, measured on the prolongation of the east boundary, and fully 125 feet from the river at the nearest point.

Taking the lines which terminate near the river, we find that the effect on the water table begins to show about 500 feet from the river, at 400 feet the depth is not quite a foot, at 300 feet it is about 18 inches, from 300 feet to the river the fall shows quite a uniform grade until it reaches nearly the depth of the channel. From this we would expect an 8-foot ditch to act from 200 to 300 feet on either side where all the water had to move laterally, in the case of water applied on the surface it would probably be effective through a greater distance.

ALKALI

The most of this flat contained quite a large amount of alkali, so much that it would have been unwise to plant it to anything except alkali resistant crops, like salt bushes; and the nearness of the water table to the surface would have unfitted a considerable portion of it for most kinds of such crops.

The alkali was practically all of the white variety, consisting of sulphate of sodium (Glauber's salts), sulphate of magnesium (Epsom salts), sulphate of calcium (Gypsum), and chloride of sodium (common salt). There was also a small amount of bi-carbonate of sodium (common baking soda), and one sample collected from the salt grass showed .25 per cent of carbonate of sodium (washing soda) or black alkali. Sulphates were the predominating salts.

Table 2 shows the composition of three samples analyzed by the writer.

Table 2

Boring Number	Sulphates SO_3	Chlorides Cl. . .	Carbonates as Na_2CO_3	Bi-carbonates as $NaHCO_3$	Lime CaO	Magnesia MgO
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
140	33.05	5.68	.25	1.01	4.99	4.78
165*a*	25.35	5.48	.00	.64	5.67	2.56
149	1.69	.11	.00	.27	1.34	.11

Number 140 is a white crust, quite pure, collected from the stalks and blades of salt grass.

Number 165*a* is a crust collected from the surface of the soil.

Number 149 is the second foot of soil, and showed a high salt content by the electrical method.

A sample of water from one of the pools near the foot of the slope was analyzed under the direction of Prof. Goss, with the following results:

Lime (CaO)	116.40
Magnesia (MgO)	389.99
Soda (Na_2O)	253.72
Potash (K_2O)	20.47
Iron, alumina and silica (Fe_2O_3, Al_2O_3 and SiO_2)	5.60
Sulphates (SO_3)	883.22
Carbonates (CO_2)	11.54
Chlorides (Cl)	248.77
Crystal water	531.71
	2461.42
Less oxygen equivalent of chlorine	56.22
Total solids	2405.20

The results of this analysis are expressed in parts per one hundred thousand parts of the water. This was a strong solution of the salts found in and on the soil, the most notable difference in composition between this solution and the salts in the soil is in the greater proportion of magnesium salts.

Table 1 shows the per cent of alkali found in the borings made on the several lines in the plat. The determinations were all made by the electrical method of the Bureau of Soils, U. S. D. A. Where the water table was within less than two feet of the surface, the alkali determinations were made only in the first and second feet of the soil.

Relation Between the Water Table and the Amount of Alkali

In Table 3 the average percentages of alkali in the first, second, and, in some cases, third foot of soil are arranged in relation to the depths of the water table with which they were associated, intervals of 6 inches being selected. The depth marked 0 shows that water was standing at or on the surface. The samples in this table include not only those of Table 1, but numerous others taken in the field both east and west of the plat.

TABLE 3

Average per cent of alkali accompanying the given depths to water

Depth to water in inches......	Line 15 feet east of center		Line 50 feet east of center		Line 100 feet east of center		Line 150 feet east of center		Average of the 4 lines on the east side......		Line 50 feet west of center......		Line 100 feet west of center......		Line 150 feet west of center......		Average of the 3 lines on the west side......		Average of all 7 lines of borings......	
	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot	1st foot	2d foot
0	.35	......	.45	.35	.40	.35	.35	.25	.40	.30	.35	.35	......	......	......	......	.35	.35	.40	.35
1-6	.40	.40	.50	.40	.35	.35	.35	.35	.40	.35	.40	.35	.30	.30	.35	.30	.35	.30	.40	.35
7-12	2.50	.55	1.50	.65	1.20	.45	.55	.40	1.45	.50	.80	.35	.60	.45	1.00	.40	.80	.40	1.10	.45
13-18	.50	.40	2.65	1.80	2.90	.60	......	......	2.00	.95	1.30	.45	1.40	.40	2.30	.40	1.65	.40	1.80	.70
19-24	2.80	2.40	3.20	1.80	2.00	.90	1.75	.75	2.45	1.45	1.40	.70	2.30	.60	1.50	1.40	1.75	.90	2.10	1.20
25-30	2.50	2.20	.80	1.45	.75	.75	2.50	1.10	1.65	1.35	......	......	......	......	......	......	......	......	1.65	1.35
31-36	......	......	.50	1.45	.95	.85	2.50	2.30	1.30	1.50	.80	1.00	1.00	1.90	1.60	1.90	1.15	1.60	1.20	1.55
37-42	......	......	......	......	1.10	1.40	.60	2.20	.85	1.80	......	......	......	......	......	......	......	......	.85	1.80
43-48	.55	1.90	......	......	......	......	......	......	.55	1.90	......	......	......	......	......	......	......	......	.55	1.90
49-54	......	......	.55	1.00	......	......	.20	1.00	.10	1.00	......	......	......	......	.35	1.40	.35	1.40	.35	1.40
55-60	......	......	......	......	......	......	......	......	......	......	2.30	2.40	......	......	......	......	2.30	2.40	2.30	2.40
61-66	......	......	2.00	2.50	.90	2.10	......	......	1.45	2.30	......	......	......	......	......	......	......	......	1.45	2.30
67-72	......	......	......	......	......	......	......	......	......	......	......	......	.60	2.40	.40	.90	.50	1.65	.50	1.65
73-78	......	......	.25	.95	......	......	......	......	.25	.95	.85	2.20	......	......	......	......	.85	2.20	.55	1.60

Where the water table was six inches or less the average percentage of alkali was .40 in the first and .35 in the second foot. This comparatively small amount of alkali is probably due to the circulation of the water, which by its movement would tend to keep the amount of alkali from increasing and should, theoretically, finally wash the salts out, provided that the concentration by evaporation was less than the amount removed. The water here is, most probably, constantly moving toward the Hondo. Another factor in this case is the absorption of a large amount of heat by the water and a consequent lessening of evaporation as the temperature is thereby kept down.

Where the water was 7 to 12 inches below, the alkali began to accumulate on the surface, because of more rapid evoporation, and because the water could not reach the salts to dissolve them out.

When the water table reached a depth of 19 to 30 inches, the maximum accumulation of alkali was found; 2.10 per cent in the first and 1.2 per cent in the second foot. Here the moisture supplied by capillarity is not sufficient in amount to exert so much cooling effect, and evaporation is greatest.

The soil acts like a lamp wick and continually draws up water from below. The depth from which water can be lifted and the rate of its rise depends on several factors the most important of which is the size of the soil particles. The rise is most rapid in sandy soils, which have the largest grains, but the depth from which the water can be raised is the least; on the other hand, compact heavy clays, which have the smallest particles, can bring water up from much greater depths, but the rate of rise is very much slower.

The maximum effect of capillarity in this soil is found at 19 to 24 inches, as is shown by the greatest accumulation of alkali, due to the greatest amount of water being evaporated, where the water table was at this depth.

The water rising through the capillary spaces in the soil takes with it the dissolved materials, and when the water evaporates at the surface of the ground, the salts are left and

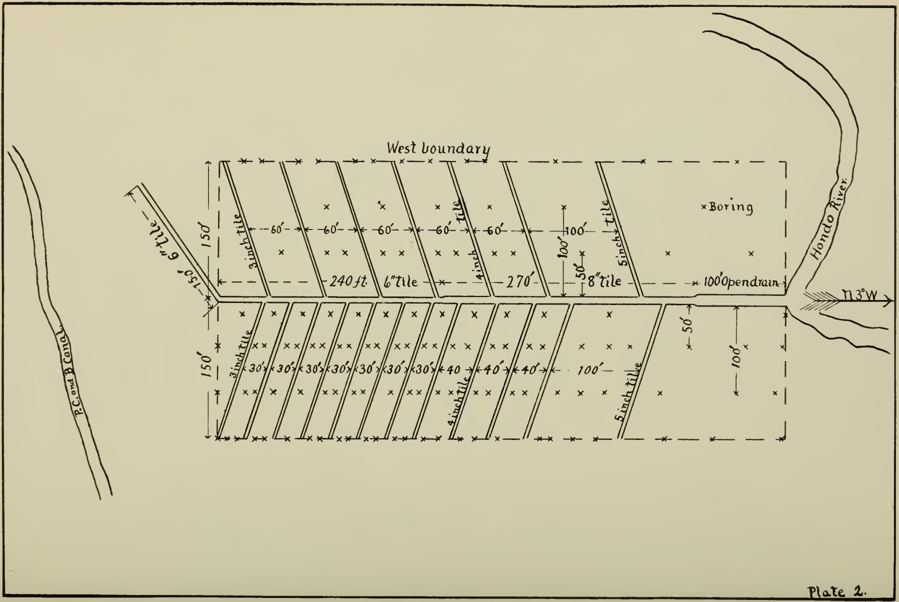

Plate 2. Plan of the drainage system

form the well known crust. We may therefore expect to find accumulations of alkali where much water evaporates from the surface of a soil, provided there is not sufficient rainfall or irrigation to wash the salts down into the soil. If the amount of salts is sufficient to be injurious to crops it will not do, in trying to improve the land, to simply wash them back into the soil, because unless carried down to a great depth they will soon be brougnt up again by capillarity, especially if the water table is near the surface. Where the water table is near the surface the first step in improving the land must be to lower it to a depth greater than that at which the soil exerts its maximum capillary power. For example, on this piece of land it would be useless to try to remove the salts from the portions where the water table is at a depth of less than 30 inches.

There are localities where the rise and accumulation of alkali are not due to the water table being too near the surface. In such cases the deeper layers of the soil are charged with alkali, and when water is added by irrigation the increased amount of water in the soil in its upward movement brings more and more of the salts to the surface. These conditions seldom if ever occur in the Pecos valley.

The source of the alkali in this piece of land, as well as that of most of the soils in the Pecos valley, is the evaporation of water containing dissolved salts. This water may be derived from surface floods which accumulate in low places, the seepage from streams and canals, or the excess of water applied in irrigation. Whatever its source this water always contains dissolved mineral matter* in greater or less amount.

Very few samples from New Mexico have been examined by the chemical department of this station, which contained less than fifty parts of dissolved material in one hundred thousand parts of water, and some samples of water used for irrigation show as much as 500 parts of solids per hundred thousand. The average composition of the Pecos river water at Carlsbad, N. M., is stated by Prof. E. M. Skeats to be 310 parts of solids per hundred thousand. The water in the canals from which this piece of land is seeped contains about 100 parts of solids per hundred thousand, and it is to be considered a good water for irrigation.

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* For analyses of a number of New Mexico waters see N. M. Expt. Station Bulletin No. 34.

Every one hundred thousand pounds of this seepage water as it leaves the canal contain 100 pounds of salts which would be left when the water evaporated, even if there were no more salts dissolved in its passage through the soil. One hundred thousand pounds of water would only give a depth of one-half inch over an acre, while evaporation under ordinary conditions probably amounts to more than a foot of water per acre per year. The amount of salt which may be deposited on an acre in a year from the evaporation of water containing a moderate amount of dissolved material, is thus seen to be very large, and this process is sufficient to account for the alkali in the piece of land under discussion. For a further discussion of the subject of alkali see Bulletin 42 of this station.

Returning to the results in table 3 we find that when the water table was at 30 inches or less the amount of alkali in the second foot was less than that in the first, where the water was below 30 inches the amount of alkali in the first foot decreased materially, except where the depth was 55 to 60 inches, while that in the second foot is several times the amount in the first. This condition is probably due to the action of rains and floods which have leached the salts from the surface foot and carried them down into the second and third feet. The water table is so far down that there has not been sufficient capillary rise of water to bring the salts up again. The exceptionally large amounts of salts found where the water table was 55 to 60 and 61 to 66 inches are due to the location of the borings. Each of these is represented by a single sample which was taken from a bare spot instead of in salt grass as were the other samples. Such bare spots are usually more salty than the covered soil and are often slight depressions, not only is evaporation more rapid from them, but there is usually some salt brought into them by the wash and the salt is left when the pools dry up.

It seems probable to the writer that much of the spotted condition of alkali soils may be due to differences in capillary power in the soil and to a lack of covering. A spot which has become bare from any cause is likely to have its salt content increased, and its chances for being covered again by vegetation are considerably lessened. It is therefore very important to try to get bare spots on alkali soils covered with alkali resistant plants, the growth of which will not only aid in preventing the spots from becoming worse, but will tend to remove some of the salts.

The Drains

The drainage system (see plate 2) consists of a main central drain 610 feet long running from the foot of the slope to the Hondo, its direction being about three degrees west of north. This drain is laid on a grade of four inches to the hundred feet. The first 100 feet from the Hondo is open, the next 270 feet is laid with 8 inch tile, and the upper 240 feet with 6 inch tile. At the foot of the slope the central drain is extended 150 feet southwest, somewhat parellel with the P. C. & B. canal, and laid with 6 inch tile.

On the east side of the centre there are twelve lateral drains making an angle of about 18 degrees with the main drain, parellel to each other and 155 feet long. The first 8, from the south, are 30 feet apart, and laid with 3 inch tile at depths between 2 and 3½ feet; the next three are 40 feet apart, laid with 4 inch tile, and their depths are from 2½ to 4½ feet, their greatest depth being where they join the main and the least at their east ends, due both to their grade and the slope of the land toward the east. The twelfth drain is 100 feet from the eleventh, is laid with 5 inch tile and has a mean depth of about 4½ feet.

On the west side of the main there are seven drains, each 155 feet long, and these also make an angle of about 18 degrees with the main. The first four are laid with 3 inch tile at a depth of from 3 to 3½ feet, and 60 feet apart, the next two are laid with 4 inch tile at a depth of from 3½ to 4 feet, and 60 feet apart. The seventh is laid with 5 inch tile at a depth of about 4¾ feet, and is 100 feet from the sixth. The end of the main drain, where it empties into the river, is about 6½ feet deep.

The slope of the land was such as to allow the east end of some of the drains to come within 2 feet of the surface, while the greatest average depth of any of them was about 5 feet. This gave an opportunity for studying the effect of various depths of water table on the rate of removal of alkali, and on the growth of crops. It was our intention to plant a portion of area to various crops in narrow plats running north to south, but unfortunately this portion of the experiment could not be carried on. The drains were put in of different sizes and at different distances apart in order to test the effectiveness of different sizes of tile and to obtain an idea of the distances through which they would work.

The work was begun on April 1 and completed by May 1st, 1900. Water commenced to flow in the ditches as soon as the water table was reached and there has been a steady flow ever since of seldom less than 75 gallons per minute. For the first few months the average flow was about 100 gallons per minute.

Effect of the Drains on the Water Table

The lines of borings, given in table 1 and shown on plate 2, were remeasured on July 20, 1900, and the water table was found to be lowered practically to the bottom of the drains. The lowering in depth was not confined to the plat but was noticeable to a distance of 300 feet east, and west of the ends of the drains, and the pools of standing water had disappeared.

The drains were all working thoroughly through the full distance between them, for if they had not been the depth to water mid way between two drains would have been less than the depth at either drain, which was not found to be the case. The depths were measured again in August, 1901, and the results were practically identical with those of July, 1900.

Figure 3 of plate 1, shows the depth of the water table before the drains were put in, the depth afterward and the depth of the drains, all on the line 50 feet east of the center.

Beginning about July 20, 1900, the whole 20 acres was heavily flooded every ten days until October. The water passed into the soil and out through the drains quite rapidly, but could not be held on the surface as long as desirable for want of suitable borders. The washing would also have been much more satisfactory if the surface had been deeply plowed, instead of unbroken and covered with salt grass sod.

Discharge of Main Drain

On August 1st, 1900, at 9 a. m. before irrigating the discharge from the mouth of the drain was estimated at about 75 gallons per minute, and its salt content, as determined from its electrical resistance was about 420 parts per hundred thousand. At 6 p. m. of the same day it was discharging about 200 gallons per minute, with a salt content of about 440 parts of salt per hundred thousand, the flat having been irrigated from about 10 a. m. to 6 p. m. On August 2d at 9 a. m. the flow had fallen to about 100 gallons per minute, but with a salt content of about 500 parts per hundred thousand. These results are a fair average of the conditions before and after irrigation. On July 21st, 1900, a break occurred in the banks of the P. C. and B. canal and the side and foot of the slope were flooded for several days. The greater portion of the water found its way into the southwest extension of the main drain through several openings which it washed through the dirt covering the tile. An examination made on July 24th showed the discharge from the mouth of the main drain to be about 200 gallons per minute with a salt content of only 140 parts per hundred thousand. This low salt content of water passing almost directly through the drains instead of through the soil indicates the amount of salts taken up by the water in passing through the soil which would be fully 300 parts per hundred thousand.

Some idea of the amount of salts removed from this area may be obtained from the following calculation: Suppose the average flow to be 100 gallons per minute, drawn from the whole 20 acres, this is about 800 pounds of water per minute. If this water gains 300 parts of alkali per hundred thousand in passing through the soil, this will amount to at least two pounds of salts per minute removed, which is 120 pounds per hour, or 2,880 pounds per day, nearly one and a half tons, which seems quite a large amount until one realizes the quantity of salts that must be removed from this 20 acres before it will be in really good condition. At a low estimate this soil contains an average of one per cent of alkali in the first two feet, and this must be reduced to four-tenths per cent before this land can be safely planted to alfalfa. A foot of soil over an acre is usually estimated to weigh four million pounds, this for the two feet over 20 acres would give 160 million pounds of soil. Six-tenths (.6) of one per cent of the 160 million pounds gives 960,000 pounds or 480 tons of salts which must be removed from this 20 acres of land in order to make it safe for most crops. The drains at the rate at which they were working could remove this amount in one year.

Effect of the Drains and Flooding on the Amount of Alkali

In the following table (Table 4) will be found a comparison of the alkali content of samples taken from nearly the same spots, and the depths to water, in March, 1900, before the drains were put in, and in August, 1901, after the drains had been in about 15 months, and the land had been flooded a number of times during the summer and fall of 1900.

TABLE 4

Boring No.	Sample	March, 1900		August, 1901	
		Per cent of salt	Depth to water	Per cent of salt	Depth to water
36	1st foot	.40	0 inches		
	2nd foot	.25			
mid way	1st foot			.45	24 inches
36 and 37	2nd foot			.35	
37	1st foot	.40	0 inches		
	2nd foot	.35			
38	1st foot	.35	0 inches		
	2nd foot	.25		.55	
mid way	1st foot			.30	22 inches
38 and 39	2nd foot				
39	1st foot	.35	0 inches		
	2nd foot	.25			
151	1st foot	.35	0 inches	.55	23 inches
	2nd foot	.35		.40	
141	1st foot	.75	8 inches	.85	30 inches
	2nd foot	.30		.60	
143	1st foot	.60	9 inches	.90	30 inches
	2nd foot	.45		.40	
135	1st foot	1.30	18 inches	.65	35 inches
	2nd foot	.45		.85	
130	1st foot	.90	21 inches	.55	37 inches
	2nd foot	.50		.95	
132	1st foot	2.30	21 inches	1.00	37 inches
	2nd foot	.60		1.65	
127	1st foot	.80	33 inches	.30	46 inches
	2nd foot	1.00		.75	

Where the water originally stood at the surface and down to 9 inches and was lowered by the drains to 22–30 inches, the amount of alkali showed a decided increase, due to its accumulation from evaporation.

Where the water table was lowered from 35–46 inches the amount of alkali showed a marked decrease in the first foot and in most cases an increase in the second foot.

The irrigation washed the salt downward but had not removed very much of it below the second foot, but evaporation had not brought it back to the surface. More than half of the salt originally contained in the surface foot was washed down, and nearly *one-seventh* of the total salts in the two feet was entirely removed.

The distribution of the salts in depth after irrigation is shown in the following table (table 5). It is to be regretted that no observations were made on the distribution in relation to depth before the land was drained. The determinations given in table 5 were made in August, 1901.

TABLE 5

	0–3 in	3–6 in	6–12 in	2nd foot
Boring No.	Per cent of salts	Per cent of salts	Per cent of salts	Per cent of salts
151	.55	.70	.45	.40
141	.55	.85	1.17	.60
143	.95	.95	.85	.40
135	.40	.45	1.10	.85
130	.55	.55	.60	.95
132	.65	.80	1.60	1.65
127	.25	.25	.40	.75

These results show that a considerable portion of the salt had not washed below the second 6 inches. The important point learned from the two tables is that the irrigation already given had produced a marked downward movement of the salts.

The Relations Between the Movement of Water and the Movements of Dissolved Salts in the Soil

Why were not the salts removed faster?

This question naturally suggests itself when one is told that this land received about ten floodings. In the first place there were no borders and the land having a decided slope as well as irregularities the water was not distributed to the best advantage. Secondly, the land was covered with native sod and the surface was compact. The influence of this surface condition will be more clearly understood in connection with the third and most important factor which is, the nature of the movement of water through a soil. The relations between the movements of water and the movements of the dissolved salts has been recently pointed out by Mr. Means* and the following discussion is largely an adaptation of his paper.

When water is applied to a soil both gravity and capillary attraction act in the downward movement. Capillary attraction is more effective in the smaller spaces between the soil grains, while gravity is more effective in the larger openings. When water percolates through a soil in the field, by far the larger part of it passes through the larger openings—those produced by insects, worm burrows, root holes, cracks and seams, large interstititial spaces formed by coarse grains, etc. The soil of this plat was especially full of seams which allowed water to pass through them readily. If the rate of percolation is measured through a block of soil in field condition, and the same block is broken up dry, so as to prevent puddling and the rate of percolation is measured again it will be found much slower in the latter case than in the former because the large spaces have been destroyed, and the water is forced to pass through the small spaces between the soil grains. The resistance to flow varies as the fourth power of the diameter of a tube, so that a much larger amount of water will pass downward through the large openings than through the smaller capillary spaces. These large openings might well be called the *gravitational spaces*, and the smaller spaces between the soil grains the *capillary spaces*.

When water moves upward through a soil to replace that lost by evaporation or removed by plants, the movement is entirely capillary and the entire film around the soil grains moves.

When rain falls upon or water is applied to a soil covered with a thin soluble crust, the material is dissolved and carried down into the soil. The downward moving wave penetrates most rapidly along the gravitational spaces, since here the resistance is least and the front of the wave is drawn laterally into the true capillary spaces by surface tension. These capillary spaces, therefore, largely fill with water from the front of the wave, and since the front of the wave contains the greater part of the salt dissolved, this salt is thus retained in the capillary spaces. As soon as the capillary spaces are filled, practically all movement in them ceases, except the very slow downward percolation caused by gravity. The movement in the gravitational spaces continues. The salt in the water which was drawn back from the front of the penetrating wave remains stationary or only escapes out into the gravitational spaces by diffusion.

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* On the reason for the retention of salts near the surface of soils, by T. H. Means, Science, N. S. Vol. XV. No. 366.

When the water is no longer supplied from the surface the gravitational spaces drain of water, carrying off a relatively small part of the soluble matter, and the evaporation from the surface causes the upward movement to commence, but this movement is entirely capillary and the whole film around the soil grains moves, and as it moves so does all of the salt, except possibly that portion held by absorption, and there is evidence which leads one to believe that the absorbed salt moves also, but rather more slowly than the film; that is, the absorbed salt shows a tendency to lag behind.

If we wish to wash the salts down the surface must be kept wet and the downward movement of the water must be made capillary rather than gravitational. One way of doing this is to break up the gravitational spaces to the greatest possible depth which may be done by thorough deep cultivation before flooding. Frequent shallow irrigations are also much more effective than less frequent deep ones.

The rate at which the water passed through this piece of land showed that the movement was principally through the gravitational spaces and the water applied would have been much more effective if the ground had been thoroughly plowed before being irrigated.

Another important factor in washing out the salts is that of soil absorption. Very little is known about this property of the soil beyond the fact that the surfaces of the soil grains have the power of holding on to dissolved salts, making them very difficult to wash out.

We thus see that the saying that "the salt follows the water downward" has to be accepted with some limitations, but this experiment indicates that the salts can be washed out in a reasonable length of time.

Cost of Drainage

The cost of the drains in this experiment can only indicate the cost per foot to the farmer, for this length of drains per acre would never be used in farm practice. The results of the work of these drains, however, give some indications of the depths and distances apart to be used in the vicinity of Roswell and elsewhere in the Pecos valley.

In this system there are approximately 3,700 feet of drain which was cut, the tile laid, and the ditches filled for a contract price of $250.00, almost 6¾ cents per lineal foot.

The cost of the tile was as follows:

1860	feet of	3 inch tile at	$ 44.00	per thousand......	$ 81 85
775	"	4 inch tile at	65.00	" "	50 40
310	"	5 inch tile at	80.00	" "	24 80
390	"	6 inch tile at	100.00	" "	39 00
270	"	8 inch tile at	170.00	" "	45 90
					$241 95

The prices given are for the tile delivered at Roswell.

To the above must be added $10.00 for hauling the tile from the depot to the farm, and $35.00 for the engineer's services, making the total cost of the completed drains about $537.00, or almost 14½ cents per foot.

Since, in the Pecos valley, the most of the water in the wet lands comes from the seepage from canals or from over irrigation on higher land the first step should be to cut off the seepage. Find the direction from which the water comes and put in the deepest possible drain on that side of the land.

An open drain will probably be most economical in most cases. In the Pecos valley it will seldom be possible to make this drain more than 6 feet deep, and its least depth should not be less than 3 feet, in fact, no drain less than 3 feet deep may be axpected to prove very beneficial. The natural drainage will then lower the water considerably, the effect of this drainage will depend upon the distance to the outlet. The Hondo channel, for example, may be expected to act for 600 feet. When the distance is greater than this put in drains 6 feet deep and 500 feet apart, and if these do not remove enough of the water, then put in other drains between these. It is impossible to tell before hand exactly how far a drain will act, and by starting with the greater distances and filling in when necessary the cost will be kept to a minimum.

Open and Covered Drains

The principal objections to open drains are, taking up considerable space, cost of bridges, cost and trouble of keeping them clean, and incidentally the danger of stock especially sheep getting into them.

Open drains take up considerable space; for example, it is practically impossible to make an open drain three or four feet deep that will not render useless a strip of land fully 6 feet wide, and this in 312 feet, (length of drain per acre, drains 100 feet apart) amounts to 1-23 of an acre, an amount too large to be left out of consideration on high priced land. Wherever such drains are crossed they of course have to be bridged which is an additional expense.

The durability of the ditch banks is, of course, a very important factor in keeping the drains clean. Some soils hold very well but in most soils it is necessary to clean the ditches once a year and in many cases oftener.

Cattle and especially sheep are liable to get into the open drains and often die before being found.

All of these objections point to the advantages to be gained by covering the drains. There are many materials which may be used to form the water way in covered drains, but tile will probably prove the cheapest and most satisfactory in the Pecos valley.

Where the flow of water is greater than can be carried by an 8-inch tile it is probably cheapest to leave the drains open and if the drains are 500 feet apart the open drains will prove saistfactory, especially where the banks stand well. Where drains have to be put in between the 500 foot ones, 3 and 4 inch tile will in most cases be large enough and should by all means be put in.

A combination of open drains 500 feet apart with 3-inch tile drains between them 150 feet apart would cost between twenty and thirty dollars per acre, the tile costing about twenty dollars.

Those interested in drainage will find valuable information in the following publications:

Farmer's Bulletin No 40, on farm drainage, which may be had on application to the Secretary of Agriculture, Washington, D. C.

Irrigation and drainage by F. H. King, published by the McMillan Company, New York. Price $1.50.

Farm drainage by Henry F. French, published by Orange Judd Company, 751 Broadway, New York. Price $1.50.

Summary

Where the water table is within six inches or less of the surface the amount of alkali is low.

The maximum effect of capillarity in Hondo meadows soil is found where the water table is about 2 feet below the surface of the ground, as is shown by the maximum accumulation of alkali.

Drains less than 3 feet deep will not be effective.

Ten floodings applied to the natural, salt grass covered, surface removed about one-seventh of the total alkali from the first two feet of soil, and carried a large amount of that formerly in the first foot down into the second.

Seepage water should be cut off by deep drains placed on the side of the land from which it comes.

Combined open and tile drains will cost from twenty to thirty dollars per acre.

N. Cat.

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New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

ASH ANALYSES OF SOME NEW MEXICO PLANTS

BY

ARTHUR GOSS

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ASH ANALYSES OF SOME NEW MEXICO PLANTS.

INTRODUCTION.

As is well known, plants differ very materially in composition and products formed. Thus we see one producing sugar, another rubber, another cotton and so on. This is not only true of the organic products formed, but also of the mineral elements contained. It was in order to study the differences in mineral contents of some of the plants of this territory that the following work was undertaken.

The plants for the study, with the exception of the chico bush, were collected in the vicinity of Mesilla Park about the 1st of January, 1902. Some were taken from alkali spots in the valley, others from the mesa bordering the valley, and still others from the mesa farther back toward the mountains, while such as the prickly pear and sotol were taken from the slopes of the mountains above the mesa.

With the exception of the alfalfa and chico bush, the amount of water contained in the plant in its natural condition was determined. In all cases the results have been calculated to the percentages of the different substances in the water-free material. Most of the determinations were made in the ash according to the A. O. A. C. methods. The nitrogen, of course, was determined in the dry plant. As it has been shown that sulfur is lost in burning, this was determined both in the plant by fusion with potassium hydrate and potassium nitrate, and, for the sake of comparison, in the ash as well. In the following table will be found the result secured:

COMPOSITION OF SOME NEW MEXICO PLANTS

Common and Scientific Name of Plant.	Per cent. Water in Plant as Collected	Per cent. Dry Matter in Plant as Collected.	In Water—Free Material												
			Per cent. Ash	Per cent. Sand and Silica	Per cent. Lime (CaO)	Per cent. Magnesia (MgO)	Per cent. Soda (Na_2O)	Per cent. Potash (K_2O)	Per cent. Iron (Fe_2O_3)	Per cent. Manganese (Mn_3O_4)	Per cent Sulphur in Plant (SO_3)	Per cent. Sulphur in Ash (SO_3)	Per cent. Chlorin (Ce)	Per cent. Phosphorus (P_2O_5)	Per cent. Nitrogen (N)
Salt grass (Distichlis spicata)	25.58	74.42	11.61	9.59	0.64	0.36	0.29	0.39	0.27	0.02	0.47	0.39	0.17	0.10	0.45
Bunch grass (Sporobolus airoides)	28.14	71.86	7.99	5.31	0.64	0.33	0.41	0.46	0.19	0.02	1.02	0.36	0.17	0.10	0.45
Sea blite (Dondia suffrutescens)	50.13	49.87	7.88	0.86	0.40	0.23	2.70	0.68	0.19	0.00	1.27	0.64	0.93	0.23	1.56
Cachanilla (Pluchea sericea)	73.99	26.01	3.44	0.60	0.42	0.62	0.76	0.32	0.12	0.01	1.99	0.36	0.42	0.07	0.51
Shadscale (Atriplex canescens)	51.07	48.93	4.23	0.46	1.00	0.64	0.24	0 97	0.15	0.02	0.70	0.19	0.08	0.12	1.25
Creosote bush (Larrea tridentata)	41.25	58.75	5.97	0.83	1.89	0.17	0.09	1.05	0.14	0.00	0.56	0.21	0.16	0.33	1.54
Popotillo (Ephedra trifurca)	36.63	63.37	7.71	0.76	3 31	0.40	0.08	0.51	0.18	0.04	0.72	0.27	0.05	0.18	0.96
Century plant (Agave aplanata Parryi)	71.80	28.20	8.87	0.43	1.63	1.22	0.31	1.13	0.10	0.00	0.24	0.10	0.03	0.31	1.11
Sotol stem (Dasylirion Wheeleri)	67.25	32.75	11.55	1.12	1.24	1.56	0.12	2.53	0.27	0.04	0.25	0.18	0.11	0.48	0.59
Sotol leaves (Dasylirion Wheeleri)	39.06	60.94	7.67	0.29	2.01	1.18	0.09	1.96	0.18	0.03	0 56	0.20	0.05	0.60	0.66
Soapweed stem (Yucca radiosa)	55.81	44.19	9.75	1.66	2.54	1.06	0.22	0.74	0.12	0.00	0.41	0.14	0.05	0.17	0.37
Soapweed leaves (Yucca radiosa)	80.57	19.43	11.03	0.46	2.29	2 12	0.40	1.40	0.13	0.03	0.51	0.13	0.04	0.61	0.96
Spanish dagger stem (Yucca macrocarpa)	71.69	28.31	11.20	1.66	2.58	1.48	0.92	0.74	0.26	0.00	0.32	0.15	0.03	0.21	0.30
Spanish dagger leaves (Yucca macrocarpa)	66.88	33.12	7.24	0.36	1.21	1.38	0.18	1.03	0.17	0.00	0.43	0.16	0.04	0.33	0.59
Ocotillo (Fouquiera splendens)	63.82	36.18	3.52	0.93	0.88	0.25	0.05	6.60	0.17	0.01	1.50	0.09	0.10	0.15	0.59
Prickly pear (Opuntia Camanchica)	87.01	12.99	7.39	0.12	1.98	0.95	0.22	1.36	0.09	0.00	0.55	0.10	0.05	0.12	0.68
Prickly pear (Opuntia macrocentra)	72.70	27.30	24.18	0.19	15.43	6.27	0.65	0.38	0.28	0.00	0.41	0.15	0.05	0.11	0.37
Tree Cactus (Opuntia arborescens)	74.99	25.01	13.63	0.15	3.21	2.08	0.34	1.37	0.16	0.00	0.42	0.19	0.09	0.26	1.27
Chico bush (Sarcobatus vermiculatus)	......	......	13.81	0.41	0.90	0.19	3.30	3.05	......	0.00	......	0.60	1.11	0.57	......
Alfalfa, first cutting (Medicago sativa)	......	......	10.53	1.07	1.79	0.10	0.32	3.23	0.37	0.00	0.94	0.52	0.73	0.39	2.58
Alfalfa, second cutting (Medicago sativa)	......	......	11.04	0.32	1.87	0.31	0.53	3.65	0.26	0.00	0.75	0.57	1.19	0.41	2.60
Alfalfa, third cutting (Medicago sativa)	......	......	8.44	0.18	1.31	0.15	0.25	3.11	0.20	0.00	0.78	0.58	0.60	0.35	2.07
Alfalfa, fourth cutting (Medicago sativa)	......	......	9.38	0.28	1.42	0.24	0.29	3.65	0.11	0.00	0.82	0.41	0.68	0.41	2.51
Average of four cuttings of alfalfa	......	......	9.85	0.46	1.60	0.20	0.35	3.41	0.23	0.00	0.82	0.54	0.80	0.39	2.44
Average of all of above plants	58.80	41.20	9.48	1.24	2.20	1.01	0.55	1.49	0.19	0.01	0.71	0.29	0.30	0.29	1.09

DESCRIPTION OF PLANT AND DISCUSSION OF COMPOSITION.

Salt grass is a coarse, low grass forming a loose sod on alkali flats in the valleys of the territory where very little else will grow and where the water table is very close to the surface. It is of considerable value as a forage plant, although not nearly so desirable in this connection as the gramma of the plains. The sample analyzed was collected from a spot so highly charged with alkali that cultivated plants would not grow there. The analysis shows the sample to be slightly above the average in ash nearly all of which is silica. The large amount of silica contained seems to be about the only distinctive feature of the analysis. It is not so high in soda, potash or lime as many of the other samples analyzed which were taken from land less highly charged with alkali.

Bunch grass, (improperly called salt grass or sacaton) is a coarse grass growing on dry alkali soils where other grasses will not thrive, forming under most favorable circumstances, a loose, hummocky sod. It also has considerable value as a forage plant. It is quite similar in composition to salt grass but contains somewhat less ash. It is also charaterized by a high silica content.

Sea blite is an herbaceous perennial weed, often confused with and called Burro weed, one to three feet in height with small fleshy leaves. It is found growing on alkali soils only, and is a sure indication of alkali. The sample analyzed was taken from an extremely bad alkali spot. The analysis shows this plant to have about an average amount of ash. The plant is characterized by a very high percentage of soda and a relatively large amount of sulfur and chlorin.

Cachanilla is an undershrub of the composite family growing from three to five feet high. It is charaterized by a single straight stem, the diameter of one's finger and smaller, to which is attached many small lateral branches. It is sometimes called arrow weed. It is abundant in many portions of the valley and affords one of the few thick growths completely covering the ground. This plant on account of its straight stem and bushy top is used by the Mexicans as a covering for adobe houses before the mud is put on. It is the lowest in ash of any of the samples analyzed. It is characterized by a relatively large amount of sulfur.

The Shad scale is a shrub from three to six feet high found growing on the plains above the line of irrigation. It is very abundant in the vicinity of the College. It is sometimes incorrectly called sage brush. It is browsed by cattle, to a small degree, in the spring. The analysis shows this plant to be comparatively low in ash. It is much lower in silica than the grasses and is relatively high in nitrogen and potash.

Creosote bush or Hediondillo is an evergreen shrub with yellow flowers. It is found growing in a zone beginning just at the edge of the foot-hills along the Rio Grande Valley. It grows from four to six feet high and has a very strong dis agreeable odor when broken. It has no economic importance. The ash content is relatively low. It is characterized by a rather high potash content but the soda is very low. It contains a considerable amount of nitrogen.

Popotillo or Cañatillo is a low shrub from two to six feet high with inconspicious scale-like leaves and tough cylindrical articulate stems of a light green color. It is found growing in the mesas, usually along the arroyos. It is used quite extensively as a medicine for venereal and kidney diseases. It is characterized by about an average amount of ash with a high lime and low soda content.

Ocotillo or Candlewood is a thorny shrub growing on the mountain slopes of southern New Mexico. It is characterized by straight resinous, thorny stems something like one inch in diameter, which are usually devoid of leaves. It has prominent, bright scarlet, flowers at the ends of the wand-like stems during the early spring. It is used by the Mexicans for making fences. The ash content is very low. Perhaps the most characteristic feature of the analysis is the relatively large amount of sulfur contained.

Century plant is a plant with large, thick, pointed green leaves which come out in the form of a rosette. The plant before flowering, reaches a height in this locality of eighteen inches to two feet. After several years, this plant sends up an inmense flower stock out of all proportion to the size of the plant, to a height of ten or fifteen feet. The effort to produce this immense flower stock is the culminating one in the life of the century plant and so exhausts it that it soon afterward dies. The plant is characterized by a moderately high ash content with low chlorin and sulfur.

Sotol is a cylindrical shaped plant with a very compact central portion from one to two feet in diameter, consisting of the stem to which the leaves are very compactly attached. The inner portion of the leaf, when alive, has very much the appearance of a flat cupped sheet of ivory. The outer portion of the leaf is green in color, and consists of a single long flat blade provided with numerous forward-pointing, curved spines on the edges. The plant sends up a long straight unbranched flower stalk to a height of ten or fifteen feet. This when covered with the small yellowish flowers presents a very striking appearance on the rocky hillsides which the plant inhabits. Sotol is used in Mexico for making an intoxicating drink. It is used to some extent as a cattle food. Owing to the large amount of easily combustible material present, it is used quite extensively by the Mexicans and Indians for making beacon fires. It is quite a common and striking sight in this locality to see a mountain side lighted up at night by sotol fires arranged in the form of a cross or other figure. The analysis of the plant shows the ash content to be relatively quite high with a large amount of potash. The stem is much higher in sand and silica than the leaves, owing perhaps to the presence of sand caught and held by the compact head. Otherwise the composition of the stem and leaves is not so radically different, but the stem contains considerably the greater amount of ash.

Soap weed or amole, is a species of *Yucca* common in this vicinity. It grows from six to twelve feet high and is distinguished from the Spanish dagger or other common *Yucca* by having a narrower, less stiff leaf, and a higher, more branched, and less compact flower stalk. The root of this plant is used as a substitute for soap and is considered very desirable for washing flannels in hard water, the hair, etc. Amole is characterized by a relatively high ash content, with a high percentage of lime, and a low percentage of chlorin.

Spanish dagger, is one of the most conspicuous plants of the southwest. It grows to a height of ten or fifteen feet, and usually consists of a single trunk, the lower portion of which is covered with a thick mass of dead leaves, hanging points downward, which afford an excellent opportunity for a quick fire. The top of the plant consists of a rosette of stiff, pointed green leaves, from the center of which is sent up, during the flowering season, a large cluster of bell-like, white, wax-like flowers, having a very heavy, somewhat sickening odor. The ash content of the *Yucca* is high, and is characterized by rather high lime and magnesia and low chlorin.

Prickly Pear, or nopal, is a well known plant growing throughout the southwest. The peculiar chain-like stems made up of green, disc-shaped, thorny sections, give the plant a very distinctive and characteristic appearance. The yellow flowers and dull red fruit are also characteristic. Certain species of these cacti grow in the utmost abundance in the lime-stone region between San Antonio and Austin, Texas, where they are among the most common plants. It is used there quite extensively as a stock food. Owing to the presence of innumerable spines of all sizes from almost microscopic filaments to needle like barbs, it cannot be used by stock until the spines are removed. This is done by burning, a gasoline torch being used to singe them off. The plant thrives best in a limestone country, and the very remarkable amount of lime contained indicates its preference in this direction. The ash content of some of the prickly pears is extremely high, Besides the unusual lime content prickly pear is also, as might be expected, very high in magnesia. It also contains considerable potash, but is low in silica, chlorin and phosphorus. The three species analyzed differ considerably but the characteristic mentioned above are common to all.

The Tree Cactus is a round-stemmed branching cactus from three to eight or ten feet in height, with crimson flowers, and dry, tuberculated, yellow fruit which resemble short joints of the stem. A low small spined form of this species is found on the sandy mesas just above irrigation level, while the larger and more spiny forms occur in the foot hills of the mountains as high as 6,000 feet altitude. They are of no commercial importance.

Chico Bush, or grease wood as it is most commonly called, is a grayish colored shrub somewhat resembling the shad scale in appearance, but with heavier, larger stems. It grows to a height of from two or three to five or six feet. The sample analyzed was collected in the Animas Valley near Aztec in the northwestern corner of the territory. In that valley are found detached patches of soil upon which nothing but the chico plant will grow. Analyses of samples of soil from such spots showed the presence of considerable quantities of carbonates of soda and potash, or black alkali. The analysis of this plant shows a remakably high ash content and the presence of very unusual amounts of soda and potash. The lime and magnesia are not remarkably high.

The alfalfa analyzed was grown in the Mesilla Valley on the ranch of Oscar Snow. An inspection of the analysis of this valuable forage plant shows the presence of a high ash content for cultivated plants. Perhaps the most remarkable features of the analysis are the extremely high percentages of nitrogen and potash. The soda is not remarkably high and the phosphorus, while considerable is not unusually high. Of the four cuttings analyzed, the earlier ones were somewhat higher in ash than the later cuttings, but the difference is not very pronunced.

The amount of the three principal fertilizing elements, nitrogen, potash and phosphoric acid, removed from the soil by alfalfa is very large. Taking the average figures for these substances; viz, 2.44 per cent N, 3.41 per cent K_2O, and 0.39 per cent P_2O_5 there is removed in each ton of dry alfalfa, 48.8 pounds nitrogen, 68.2 pounds potash, and 8.2 pounds phosphoric acid. At eastern prices for these substances, of say 15 cents per pound for nitrogen, and 5 cents per pound each for potash and phosphoric acid, each ton of dry alfalfa has a value of $11.14 in fertilizing material contained. It can be seen that if it were necessary to supply all the nitrogen, potash and phosphoric acid contained in alfalfa in the form of commercial fertilizers, there would be no profit in alfalfa production. Fortunately, however, this plant, being one of the legumes, has the power of taking a large portion of its nitrogen from the atmosphere, and the muddy water of such streams as the Rio Grande, if used plentifully, will furnish all the potash and at least a large portion of the phosphoric acid required.

As has been pointed out in previons bulletins of this station, the fertilizing value of muddy, irrigating water, such as that of the Rio Grande, is very great, and gives the farmers in the valleys of such streams a decided advantage over the farmers of the eastern states where there is practically no addition of the mineral fertilizing elements to the soil in the rain-fall, and it is necessary after a comparatively short time to supply in part the fertilizing elements removed by cropping, by the use of expensive fertilizing material.

General Conclusions

Plants such as *Yuccas*, sotol, and prickly pear growing on the arid plains and hill sides where there is very little moisture in the soil, seem as a rule to be very high in ash, although there are exceptions such as Ocotillo. In general, all the plants of this region seem to average higher in ash than the plants of the rain-fall districts. This is probably due to the more concentrated solutions of mineral matter present in the soils in which they grow.

In regard to the mineral contents of plants growing on alkali soils, there does not seem to be very much uniformity. Salt grass and bunch grass, for example, while containing something like an average amount of ash, are much lower in soda, potash, lime, magnesia and the other elements usually found in alkali, than many of the plants growing on soils containing much less alkali. The principal portion of the ash of these grasses is silica which does not form a part of alkali at all. On the other hand, the sea-blite and chico bush, both alkali loving plants, are very high in soda and some of the other elements found in alkali, and do not contain nearly so much silica as the grasses. Again, in this connection, the prickly pears taken from a limestone hill are very remarkably high in both ash and lime, whereas, ocotillo, taken from the same place, is low in both ash and lime. It would seem, therefore, that the species of the plant has perhaps more to do with its mineral composition than the environment under which it grew.

The use of alkali resisting plants, such as the Australian Salt bush, has been suggested as a means of removing the excess of alkali from land. It is possible that the sea-blite which thrives on alkali land in this locality and which contains large amounts of soda and chlorin might be found useful in this connection. Owing to the comparatively small amount of alkali taken up, salt grass and bunch-grass would not be of much use in this connection. It is evident, of course, that in order to derive any benefit from the use of such plants, they would have to be cut off and removed from the land; as otherwise the alkali contained would go back on the land when the plant decayed.

Sulfur Lost in Burning.

It has been known for a long time that a considerable amount of the sulfur of organic substances sucn as plants, is lost in burning the material to ash, In some cases, a small amount of phosphorus may also be lost in this way. Mr. H. C. Sherman has shown, however, in the November issue of the Journal of the American Chemical Society, that the loss of phosphorus in ignition was very slight indeed in the case of several organic substances with which he experimented, and as this has been the writer's experience, in the case of ordinary plants, the phosphorus was determined in the ash only in the work reported in this bulletin.

A comparative study, however, was made of the sulphur present in ash and unburned plant material. Sulphur in the ash was determined by the A. O. A. C. method. Sulphur in the plant was determined by fusion with KOH and KNO_3 as recommended by C. P. Beistle, of the Pennsylvania Experiment Station, in the November number of the Journal of the American Chemical Society. This method was found to work well with the exception that in following Mr. Beistle's directions, a lot of platinum ware was almost ruined We were aware that the standard texts cautioned against the fusion of caustic alkalies in platinum, but supposing that Mr. Beistle had tried this and found the action to be slight, we followed his directions without question, with the result that the platinum used was very seriously attacked. The loss in some cases amounted to as much as half a gram. The vessels finally used for the determination were large iron crucibles. These were attacked to some extent but the dissolved iron was found not to interefere seriously, and the sulphur present in the same was not enough to cause trouble. The crucible used should be large, about 100 cubic centimetres and the heat applied gradualy at first, as the fusion mixture has a tendency to boil over at the start.

As to the results, it will be seen by referring to the table that the sulphur in the ash was less in every case than in the plant. The average for all the samples was 0.29 per cent in the ash and 0.71 per cent in the plant. The per centage of sulphur lost in burning is not the same in different plants, ranging from 34 per cent as the average for the four cuttings of alfalfa to 94 per cent in Ocotillo. From this it will be seen that the determination of sulphur in the ash with a view of determining the amount originally present in the plant is absolutely worthless.

Acknowledgments

A number of the plants analyzed were collected by Mr. Matthew Steel, a student in the college. A large amount of the analytical work was done by Mr. C. L. Post, assistant in the chemical department. A few analyses were made by Mr. S. W. Swing. Prof. E. O. Wooton kindly furnished the scientific names of the plants, and corrected the descriptive data for the same.

Summary

1. The plants of the arid region averaged very high in ash contents. Some of them, such as the prickly pear, contain very remarkable amounts of mineral matter.

2. There is a very decided difference between different species of plants in the amount and kind of mineral matter contained. This is the case even with plants growing on alkali soils containing a large excess of soluble mineral matter. The species of the plant probably has quite as much to do with the composition of its ash as has the environment under which it grew.

3. The amount of fertilizing material contained in alfalfa is very large. The value of the nitrogen, potash, and phosphoric acid contained in a ton of dry alfalfa, at current eastern market rates, is more than $11.00. This means that alfalfa will exhaust the fertility of land very rapidly unless the supply of plant food is kept up from some outside source. By the use of plenty of muddy irrigating water, such as that of the Rio Grande, this is accomplished, and the money outlay necessary for fertilizers in eastern agriculture is avoided.

4. The determination of sulfur in the ash of a plant is of no value whatever as a measure of the amount present in the plant. On the average, but little more than one-third as much was found in the ash as was present in the plants analyzed.

Neither is the proportion between the amount present in the ash and in the plant constant but varies with different species of plants.

N.Cat.

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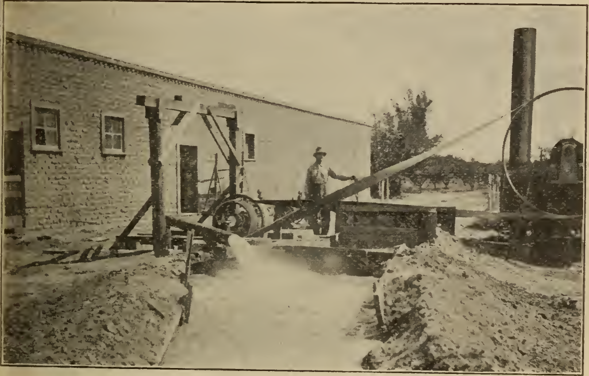

PUMPING FOR IRRIGATION
FROM WELLS

BY

JOHN J. VERNON and FRANCIS E. LESTER

SANTA FE, N. M.:
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Fig. 17. Discharge thrown from seven-inch pipe by the Van Wie No. 5 Centrifugal Pump, running at a speed of about 750 revolutions per minute.
Fig. 18. Exterior view, R. D. Wood Co's. Centrifugal Pump, double side suction type.
Fig. 19. Interior view R. D. Wood Co's. Pump illustrated in fig. 18.
Fig. 20. Discharge thrown from a six-inch pipe by the R. D. Wood Co's. No. 6 Pump, running at a speed of about 900 revolutions per minute.
Fig. 21. Kingsford Centrifugal Pump, vertical single bottom side suction type.
Fig. 22. Discharge thrown from a six-inch pipe by the Kingsford Centrifugal Pump No. 6, running at a speed of about 640 revolutions per minute.
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Fig. 24. Discharge of about 1,000 gallons a minute thrown from an eight-inch pipe by the Byron-Jackson Centrifugal Pump No. 6.
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Fig. 26. Discharge of about 500 gallons per minute thrown from a five-inch pipe by a Byron-Jackson No. 4 Centrifugal Pump.
Fig. 27. Exterior view of Johnson Rotary Pump; front single suction type.
Fig. 28. Interior view of Johnson Rotary Pump shown in Figure 27.
Fig. 29. Discharge of about 330 Gallons Per Minute thrown from a five-inch pipe by Johnson Rotary Pump No. 5.
Fig. 30. Competitive Test of Pumps at the El Paso, (Texas) Carnival, January 18, 1902. Water pumped from Open Tank, with lift of nine feet. Slanting pipe from six inch

Johnson Rotary Pump discharging 700 gallons per minute; horizontal pipe from six-inch Byron-Jackson Centrifugal pump discharging 800 gallons per minute.

Fig. 31. A Gould's Endless Chain Bucket Pump used by Mann Bros., of Albuquerque, for Irrigating.

Fig. 32. Discharge of about 450 gallons per minute through a six-inch pipe from pump of J. Stoney Porcher, El Paso, Texas.

Fig. 33. Discharge of about 300 gallons per minute through a six-inch pipe from pump of E. J. Hadlock, El Paso, Texas.

Fig. 34. Irrigating Ditch filled by pump of E. J. Hadlock referred to in fig. 33.

Fig. 35. Discharge of about 450 Gallons per minute through a seven-inch pipe from pump of Julius T. Porcher, El Paso, Texas.

SUMMARY

1. An ample quantity of water for irrigating purposes exists throughout the Rio Grande Valley in Southern New Mexico at a comparative shallow depth.

2. This water, termed the underflow, can be easily made available by sinking pipe wells, with slotted strainers, into the gravel strata at comparatively low cost.

3. The station at Mesilla Park sank an experimental well six inches in diameter and 48 feet deep from which was pumped a continuous stream of over 1,000 gallons a minute.

4. From this well it was found possible, using a 20 horse power steam engine with tornillo wood as fuel, to irrigate average land three inches deep at a maximum cost of from 51 cents to 64 cents an acre, according to the pump used. This estimate is for short runs; for long runs this cost will probably be reduced, a point to be determined later.

5. Eight pumps of various types and sizes were tested by the station upon the well above referred to and comparative results are set forth in tabular form.

6. A comparative test of four kinds of fuel was made and the results are compiled in tabular form.

7. Data concerning pumping plants in New Mexico and other states has been collected and is compiled and presented in tabular form under the heads of Wells, Pumps, Engines, Lands Irrigated, and Railroad Pumping Plants.

8. A study of the relative conditions existing in New Mexico and other states, shows that, in the Rio Grande Valley in Southern New Mexico at least, the conditions are unusually favorable for the successful and economical operation of pumping plants as a means of supplying water for irrigating purposes.

INTRODUCTION

Without water nothing will grow. It is as much a necessity to vegetable life as air or light. Moreover, to secure the best results vegetation requires water at certain intervals. Nature sometimes fails to provide this supply when most required, and the work of man steps in with the practice of irrigation. Herein lie the advantages which irrigated regions possess over those which rely solely upon the rainfall.

New Mexico is blessed with a genial climate and, for the most part, with a fertile soil. The conditions existing in her valleys and on many of her plains are, except for the matter of rainfall, exceedingly favorable to agricultural pursuits. Farming operations may here be carried on the whole year through. But the amount of rainfall in the territory is light, averaging in different localities not more than 8 to 16 inches in the year. This being the case, it is evident that the solution of the problem of successful agricultural work in New Mexico is a sufficient quantity of water for irrigation. It was with a view to demonstrate the practicability of providing such a supply of water from the underflow that the experimental work described in this bulletin was undertaken.

The funds available for the prosecution of the investigation conducted were limited, but enough has been done to emphasize its importance to the development of the agricultural interests of our territory.

DEVELOPMENT OF PUMPING PLANTS

Irrigation by pumping, no doubt, grew out of gravity systems. From irrigation by gravity it was only a step to that of pumping from river channels and canals to high-lying contigous areas. In natural sequence, pumping would follow upon lands lying slightly above gravity systems or upon areas having no water supply other than that of the underflow.

Irrigation by pumping dates far back in history. "We are told that 'the numerous remains of huge tanks, dams, canals, aqueducts, pipes and pumps in Egypt, Assyria, Mesopotamia, India, Ceylon, Phœnicia, and Italy, prove that the ancients had a far more perfect knowledge of hydraulic science than most people are inclined to credit them with.' "*

At the present time much greater areas are irrigated by pumping from wells than is generally supposed. King, in writing on this subject says: "It is further estimated for the whole Indian Peninsula, British and native, that no less than 300,000 shallow wells are in use, while they serve certainly more than 6,000,000 acres of land." Large areas are being successfully irrigated by pumping from wells in the various sections of the United States, notably, parts of the great rice region of the South; considerable areas of fruit lands in California; and certain alfalfa and fruit sections in Colorado, and elsewhere.

GENERAL IMPORTANCE AND LOCAL CONDITIONS

Few parts of New Mexico are favored with an abundant supply of water for irrigation purposes. To one familiar with the agricultural conditions of the territory, it is hardly necessary to emphasize the importance of such a supply. In an irrigated region it may mean all the difference between heavy loss or large profit in the management of a farm.

Throughout the whole length of the Rio Grande Valley in New Mexico, which includes a large part of the lands of the territory at present devoted to agriculture, there has seldom been in the past ten years or more, a sufficient quantity of water in the river thoughout the irrigating season to meet the demands of the lands at present in cultivation. With the increase of the area in cultivated lands, the conditions grow worse instead of better. Enterprises that have sought to make the existing supply available for a greater length of time by means of storage reservoirs have been contemplated but never successfully completed. As a result, the average New Mexico farmer in the Rio Grande Valley has been impressed with the necessity of turning his attention to means of supplementing the available water supply. The question of pumping for irrigation is therefore of great importance in the first place, to such farmers. In the second place, it affects the question of reclaiming immense areas of fertile lands suited to agriculture that exist in New Mexico, and that lack only a water supply to bring them into cultivation: As a means of providing such a water supply the question of pumping for irrigation is attractive for two reasons. If it can be shown to be successful at all, it provides a supply that is reliable and secure, subject to no fluctuation beyond possible breakage of machinery, and making it possible to put the water on the land at the exact time required. Secondly, it places the farmer in an independent position, making him independent of water companies or ditch corporations with their sometimes annoying regulations.

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* King, Irrigation and Drainage, p. 66.

Local Conditions

The conditions existing in the Mesilla Valley, where the experiment station is located, are probably fairly typical of those to be found throughout the greater part of the valley of the Rio Grande. Largely as a result of shortage of water in recent years, the farmers of the Mesilla Valley have turned their attention to the cultivation of those crops that can not be seriously injured by an uncertain water supply. Chief among these crops, is alfalfa, and in the Rio Grande Valley, at least, the cultivation of orchards, vineyards, corn and vegetables on lands relying entirely upon river water for irrigation has received much less attention in recent years than formerly. Few farmers have cared to go to the expense of planting a crop or orchard, and cultivate it perhaps for years with the risk of a possible loss of the entire crop, from shortage of water through the summer months.

SOIL STRATA AND UNDERFLOW IN THE RIO GRANDE VALLEY

No very definite statements can be made regarding the soil strata of the Rio Grande Valley in the absence of a systematic investigation of the question. We can only be guided by the incomplete data secured on this important question from the little work that has been done up and down the Valley. From this it becomes apparent that conditions do not vary much throughout the length of the Rio Grande Valley in New Mexico which is cultivated. In a general way, the valley consists of made lands, that is to say, sand, gravel and sediments that have been washed down and deposited in the valley through past ages. What the depth of this deposit is, it is impossible to state with any degree of accuracy but it is undoubtedly very great in some parts.

Soil Strata

The various strata found throughout the valley consist of layers of soil, sand and gravel, of varying degrees of coarseness, with occasional layers of hardpan or clay. Sand evidently forms the greater part of the strata in the valley and in many parts extends to the surface, although usually covered by a layer of sediment and rich soil varying in thickness from a few inches to many feet. It seems to be generally true that most of the valley is underlaid at a reasonable depth with gravel beds sufficiently thick to procure from them by means of slotted strainers an ample water supply. In the Mesilla Valley a gravel bed is usually found at from 20 to 80 feet in depth although there is no certainty as to the depth at which it will be found or the thickness of the stratum.

Along the foot-hills of the valley the question of underlying strata is a much more uncertain one, but in the valley proper we know that large quantities of sand and varying thicknesses of gravel will be met with. Only more extensive exploitation will demonstrate what may reasonably be expected to be encountered in sinking a well.

Underflow

When it comes to the matter of underflow the question is no uncertain one. Throughout the whole length of the valley proper, water will be found at a depth of from 4 or 5 feet to 20 or 30 feet, depending upon the height of the ground above the level of the river bed. This water appears to be generally of a good and fairly uniform quality throughout the valley, though near to the foot-hills the quality is an uncertain thing. In the matter of quantity, it seems to be more a matter of providing means for making the water available than any question as to the underflow. Some New Mexico farmers using gauze covered strainers in a small size quite unsuited to the securing of large quantities of water, have met with very unsatisfactory results, as the strainers have filled up and the flow greatly diminished; and they have come to the erroneous conclusion that the water was not there. Where suitable strainers have been placed in a gravel bed which allows the free passage of the water to the well there has been no complaint of the amount of the supply.

The whole valley appears to be underlaid with water. Whether this is an immense reservoir or a river flowing in any direction is not certain, arguments being advanced to support both theories. We do know, however, that the amount of water below is enormous and amply sufficient to meet all reasonable needs. It is probably safe to say that a sufficient quantity of water exists under every acre of irrigable land in the Rio Grande Valley which if raised to the surface would irrigate it; and there seems to be no reasonable ground for believing that this supply will cease to exist.

WELLS

For convenience, wells may be classified under two heads, viz.: open wells and pipe wells. The latter are sometimes termed driven wells. For the purpose of this bulletin, an open well is defined as one in which no part of the well is utilized as an aid either in lifting or directing the water to the surface of the ground. A pipe well, on the other hand, is one to which the pump is directly attached to the well itself; it therefore, may be said to form a part of, or a necessary adjunct to, the pumping machinery. Some wells, are not, strictly speaking, under either of these heads, but for the present discussion such may be ignored, since all wells referred to in this bulletin come in one or the other of these classes.

Open Wells

Everything being equal, that is, in capacity, cost, ease of sinking, and the life of the well, the open well is the better. Under the conditions existing in the Rio Grande valley and other similar areas, the open well, however, is a difficult and costly undertaking, and until improved and less expensive methods are devised, the first cost of an open well will preclude its general adoption. By referring to the tables shown in this bulletin, it will be seen that the experimental six-inch station well, costing $150, has a capacity equal to or greater than that of open wells, costing several thousands of dollars. A number of open wells costing considerable more than this six-inch pipe well, have a less capacity. Nevertheless, the open well or its equivalent, with its accompanying minimum cost for lifting the water to the surface of the ground, is the ideal that should be constantly borne in mind.

Method of Sinking

A large area of the irrigable land in New Mexico is underlaid with sand, and the great difficulty in sinking wells in such sand arises from the tendency of the sand to move with the water; "since the specific gravity of sand is only about 2.65, just as soon as a pressure greater than three feet is developed to force the water out of the sand, the sand must move with it." * In sinking an open well, it is usually necessary to remove the water as fast as it accumulates. The effort must, therefore, be to minimize the movement of the sand which is forced upward into the bottom of the well by the pressure from without.

There are two principal methods used where sand forms the bulk of the under-stratum. The first of these is to sink the well only a few feet below the water level, and then sink several perforated pipes or strainers in the bottom of the well. These pipes will usually flow when the head of water in the open well is pumped off. The second method, and the one by which probably the most permanent well can be secured but at a comparatively high cost, is by building a circular wall of masonry, say two feet thick, upon a platform supported by a wooden curb some two inches thick, and from 4 to 6 feet long. (See Fig. 1.) The weight of the wall causes the curb to sink deep into the sand, considerably in advance of the excavation within. The pressure of the sand and water within the curbing thus tends to equalize the pressure from without and, therefore, to greatly expedite the work. In making an open well of this type, it is usually desirable at the finish to have the curbing penetrate a short distance into the gravel stratum so as to shut off further entrance of sand into the well from without the wall. In sinking the water is usually kept down by a centrifugal or other kind of pump capable of handling a large quantity of water.

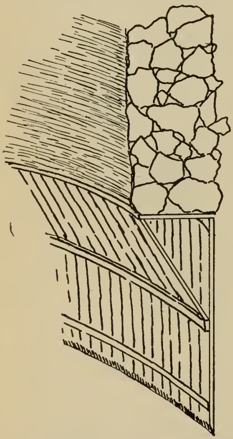

Fig. 1. Masonry curb on wooden platform.

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*King, Physics of Agriculture, p. 281.

Pipe Wells

Pipe wells are frequently sunk by drilling. Under the conditions existing in the Rio Grande Valley, however, in which sand or sand and gravel, form the water bearing stratum beneath the the surface of the soil, they are either driven or sunk by means of a sand-bucket, in which case, some form of strainer is common. With small wells three inches or less in diameter, the strainer or point, as it is frequently termed, is fastened to the lower end of the pipe and driven with the pipe to the desired depth. Large wells of this type have been driven, but it is customary with such large wells to sink the open pipe first and lower the strainer inside to the bottom. The pipe is then jacked up until the entire length of the perforated part of the strainer is exposed.

Strainers.

There are three types of strainers: The common strainer, consisting of a perforated pipe covered with brass gauze or closely wrapped with brass wire; the "Cook's" (a strainer consisting of a pipe cut with horizontal slots, wider on the inner side); and the slotted strainer. The first two are too well known to require special mention here. They are used largely to secure water from sand. The last named strainer which is illustrated in Fig. 12, consists of a pipe perforated by round holes or oblong slots, and is used in drawing water from a gravel, or a gravel and sand, stratum.

Influence of Capacity

An increase in the capacity of a well means that more water can be secured by pumping off the same head, or that the same amount will be supplied when pumping off a somewhat less head. In the latter case, the water would stand nearer the surface of the ground while pumping, and for this reason, the lift would be less, thus reducing the cost of pumping. It is evident, therefore, that the cost of pumping a given volume of water diminishes with the increase in the capacity of the well. It naturally follows that a saving in the cost of pumping will soon compensate for the relatively larger expenditure for the construction of a well of greater capacity. The size of the well, and the length of the strainer both affect the capacity of the well, if the water enters from the bottom or through the sides near the bottom.

Size of the Well

The area of the bottom, as well as that of the sides of the well, increases as the well grows larger, and it is thus evident that the greater the area the greater the space through which water can enter the well. From this we conclude that the capacity of a well, other things being equal, increases with its size.

Length of Strainer

Under equal conditions, and within the limit of the carrying capacity of the pipe, it may be said that the longer the strainer the greater its capacity. This increase in capacity is brought about in much the same way as the increase in the capacity of the well with its size. King says: "Leaving the bottom of the well out of consideration, it is clear that doubling the depth of the well in the water bearing beds doubles the area for water to enter. * * * * . This capacity increases in a somewhat slower ratio than the depth, * * * * . "* This statement also applies to the increase in capacity of a well through its increased size.

Depth of Well

So long as the head of water while pumping is above the strainer, the depth of the well does not affect the capacity, unless the conditions differ. This statement refers to pipe wells with strainers.

THE STATION WELL

The experiment station well is 48 feet deep, and consists of an open well dug to water level, in the bottom of which is sunk a six-inch pipe, 21½ feet long, with a 12 foot strainer below the pipe, located in a water-bearing gravel stratum. To facilitate the attachment of pumps, the pipe was allowed to project six inches into the open portion of the well.

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*Physics of Agri., page 278.

The following equipment and materials were used in sinking the well:

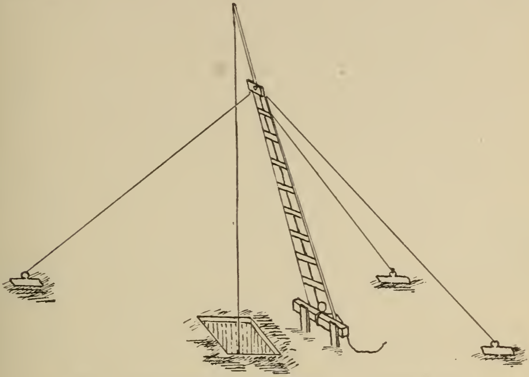

Fig. 2. Timber derrick used in sinking the Station well.

Equipment

Derrick. The derrick used consisted of a ladder, made of 3 by 8 inch pine, 22 feet long, with an extension piece 4 by 6 inches, 6 feet long, in the end of which was placed a pulley. Three 1 1-4 inch guy ropes were used to hold the derrick in position (See Fig. 2). Any form of derrick may be used, provided, of course, it is stable and of sufficient height to allow ample space between the end of the pipe and the pulley for the free play of the sand-bucket and drill.

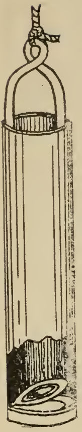

Fig. 3. Common type of sand-bucket.

Sand-Bucket. The sand-bucket used was of the piston or plunger type. (See Fig. 3). This type of sand-bucket operates on the same principle as a suction pump, by simply letting the plunger to the bottom of the sand-bucket, raising it up and down a few times until sufficient sand and gravel is drawn by suction into the bucket with the water, raising the sand-bucket out from the well, empting it, and lowering it again into the well. A cheap sand-bucket which will do satisfactory work may be made by any blacksmith, by putting a bail on the top, and a valve in the bottom, of an ordinary pipe. This pipe should be slightly smaller than the well pipe, and from 3 to 5 feet long. The length, however, may vary, but should be such as to be conveniently handled. (See Fig. 4). With this type of sand-bucket, the whole bucket must be moved up and down in filling, requiring more work than the plunger type above described. It is, however, a lighter bucket, which compensates somewhat for the extra effort in filling. It is usually best to raise the sand-bucket up some distance, and allow it to drop, as by coming down with some force, the water and sand open the valve in the bottom and rush inside.

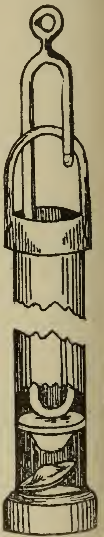

Fig. 4. Plunger type of sand-bucket used in sinking Station well.

Drill. The drill used was simply a piece of steel half an inch thick, three inches wide, eighteen inches long, properly pointed and hardened. This was threaded so as to be attached to a 1 1-4 inch pipe, eighteen to twenty feet in length, in order to give it weight. A ring was fastened in the upper end of the pipe in which to tie the rope. (See Fig. 5.)

Rope. A 3-4 inch rope 200 feet long was used on the sand-bucket and drill. In sinking a well, the length of the rope will depend upon the depth of the well, height of the derrick, whether or not a horse is used, and if so, whether the filling is done by a horse or by men. This, however, will be more fully explained in discussing the sinking of the well.

Clamps. Two sets of heavy wooden clamps were fastened upon the pipe with bolts to support the sacks of sand or other weights. (See Figs. 6 and 6½)

Weights. From ten to sixteen sacks were filled with sand and used as weights for assisting in settling the pipe, and to insure that it keep pace with the sand bucket during the sinking of the well. In the regular business of sinking wells of this character, heavy iron weights with rings attached would doubtless be preferable to sacks of sand, but for those contemplating the sinking of their own wells, the latter will prove entirely satisfactory.

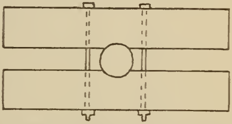
Fig. 6. Clamps used on well pipe during sinking to support weights; (top view.)

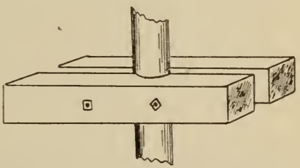
Fig. 6½. Side view of clamps shown in Fig. 6.

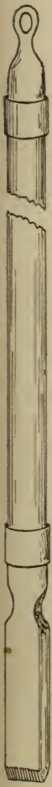
Fig. 5. Drill used in sinking the Station well.

Wrenches. Two heavy chain pipe wrenches were used for connecting and disconnecting pipes, and for turning the well pipe while sinking.

Miscellaneous. Hammers, small wrenches, nails, rope, plank for platform, timbers for holding pipe perpendicular in starting, etc., completed the equipment.

Material. Below is given a list of the materials used:

Lumber for the curb; one length 21½ feet, standard black pipe six inches in diameter; one No. 16 gauge galvanized iron strainer, 14 feet long, perforation extending for 12 feet.

Curbing

The curb was made 8 feet wide and 9 feet long from two inch Texas pine. This size was necessary in order to facilitate the exchanging of pumps tested. In a private plant, however, the curb should be of a size to suit the pump to be installed. At the top of the curb a heavy timber, six by eight inches, extending 3 to 4 feet beyond each end of the curb, was securely bolted to each side in order to prevent the curb from settling. (Fig. 11 illustrates a good type of curbing.)

Sinking the Well

With the station well, the open portion was dug, the pipe sunk, and the strainer placed, before the curb was put in place. This was found to be a mistake by reason of the fact that, owing to the splashing of water, etc., the soil caved in and much difficulty was encountered in placing the curb, necessitating an amount of extra digging before it could be satisfactorily accomplished.

After the open portion of the well was dug, the location of the pipe was decided upon, and the derrick was then raised and placed in a slanting position in such a manner that the rope swung entirely clear, and fell upon the point selected for the pipe. The guy ropes were fastened to "dead men," consisting of eight-inch logs, laid about three feet in the ground, and the derrick securely anchored at its base to two posts set deep in the soil. A hole was dug as deep as possible where the pipe was to enter, and the latter was then put in position. Before placing the pipe, however, slanting teeth about an inch deep were cut in its lower end for the purpose of assisting in moving aside any gravel that might impede the progress of the pipe, or in order to cut through any hard-pan that might be encountered. (See Fig. 7.) Care was taken to have the pipe perpendicular at the start, and timbers were placed on all four sides both at the top and bottom of the open portion of the well so as to keep it perfectly plumb until it had penetrated the earth to a distance of several feet. This is an important feature in well construction of this kind. Great care should be taken to keep the pipe perpendicular at all stages of the sinking of the well, as otherwise it may be out of plumb when the well is completed, causing consequent difficulty in properly connecting the pump.

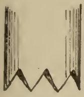
Fig. 7. Showing the teeth cut in lower end of well pipe to aid in sinking.

Using the Sand-Bucket. Weights were placed and the sand-bucket was then brought into requisition. The pipe settled about 4 feet in five minutes. More weights were added as needed, and the pipe turned frequently with the large pipe wrenches. Frequent turning of the pipe was found to expedite its sinking. The pipe would often seem to be stuck, but upon giving it a few turns it would settle down several inches, and occasionally drop almost a foot at a time. It is probable that more weights and more frequent turning would have made the pipe precede the sand-bucket all the time. This would have been an advantage, inasmuch as during the sinking of the pipe the sand-bucket two or three times preceded it, so that the flange around the outside at its lower end became fastened under the end of the pipe, necessitating jacking up the latter before it could be extricated. With a common sand-bucket this difficulty would not have been encountered.

Necessary Labor. It requires three strong men to draw a well filled sand-bucket out of the well, continuing the work from day to day. The work, however, may be done by a horse during the entire operation. In sinking the station well, a horse was used part of the time and was found entirely satisfactory. In order to fill the sand-bucket by horse power, the rope instead of being tied to the single-tree was merely run through the ring of the single-tree, while a man grasped the double rope a few feet from the horse as illustrated in figure 8. After the sand-bucket was raised a sufficient distance, the man let go of the rope, thus allowing it to run back with the weight of the falling sand-bucket. As soon as the bucket struck the bottom of the well, the rope was again grasped quickly as before, the operation being thus repeated again and again until the sand bucket was filled, the horse moving forward all the time. The horse was then brought back to the well and the sand-bucket drawn out and emptied. By using a horse, one man and the superintendent who may empty the sand-bucket, can sink a well, if strict economy is required, but it usually saves time to provide two men in order to handle the weights and turn the pipe with ease. Without a horse there should be three good men in addition to the superintendent.

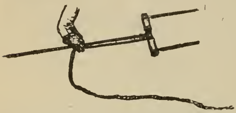

Fig 8. Single-tree with rope, illustrating the adaptation of horse power in sinking.

Gravel was struck at a depth of 32 feet, and the teeth in the bottom of the pipe were found to be of great assistance in pushing aside the gravel during the turning of the pipe. The drill was used occasionally in order to loosen the bed of gravel, and to break any stones that were too large to enter the sand-bucket. The pipe was sunk a few feet below the gravel so that the strainer could be located at the proper place without interference from the sand rising through the bottom of the pipe. The strainer was fastened to a $1\frac{1}{4}$ inch pipe with a fine copper wire strong enough to support its weight, and yet sufficiently thin to be easily broken when the small pipe was withdrawn. Just before lowering the strainer into the well, the sand which had accumulated in the bottom was removed with the sand-bucket, the strainer then being lowered and the small pipe securely anchored at the top, thus leaving the strainer suspended. (Fig. 9). The small pipe to which the strainer was fastened was closely watched during this operation to guard against any possible displacement of the strainer by the upward thrust of the sand. The well pipe was then jacked up until all of the perforated part of the strainer was left exposed, as shown in Fig. 10.

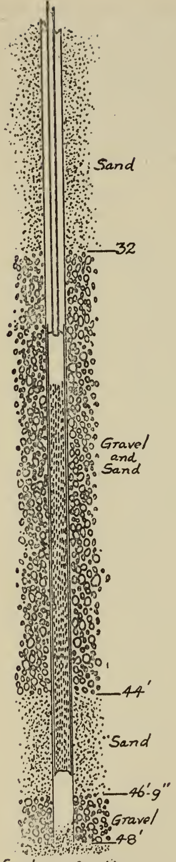

Fig. 9. Slotted strainer suspended in well by one-fourth inch pipe prior to placing.

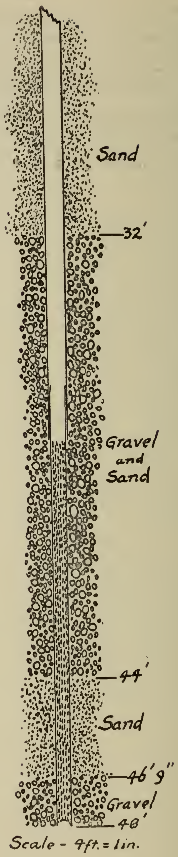

Fig 10. Strainer in place, well pipe jacked up. (Note the position of sand and gravel before any pumping has been done and compare with Fig. 11.)

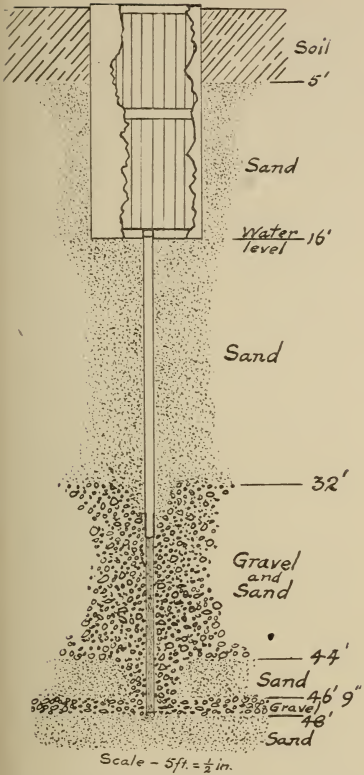

Fig. 11. Showing the Station six inch well, with curb 8x9 feet by 16 feet deep The position of sand and gravel strata are shown after the well has been pumped for some time. (Compare with strata shown before pumping in Fig. 10)

Soils Penetrated

Figure No. 11 illustrates the soils penetrated. It will be seen that the first five feet of soil consists of heavy clay (adobe). Beneath this was sand of varying fineness to a depth of 32 feet, when a gravel stratum 12 feet thick was encountered mixed with from 20 per cent. to 50 per cent. of sand. Below this gravel stratum came another of sand three feet thick, followed by another gravel stratum one foot thick.

Strainer

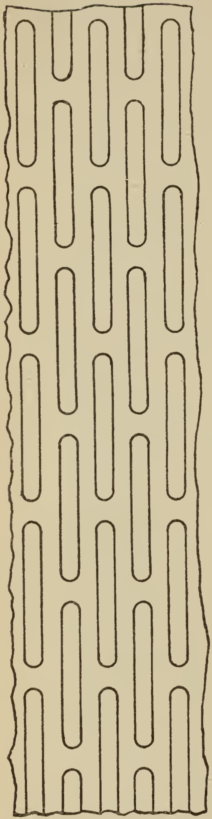

Fig. 12. A section of the wall of the slotted strainer used in Station well; slightly reduced in size.

The strainer used, a small section of which is shown in Fig. No. 12, was 14 feet long, closed at the bottom and made of No. 16 guage galvanized iron, 12 feet of which was perforated with holes 1½ inches long and ¼ inch wide, the intervening spaces being of like dimensions. This type of strainer furnishes the largest safe amount of open space through which water can enter the well. The openings are sufficiently large to permit all the sand to enter the well and be pumped out, and at the same time small enough to restrain the gravel, thus forming a very porous water-bearing stratum. One or two feet of blank at the top of the strainer is important, so as to avoid possible danger of disconnecting the pipe and strainer.

The El Paso Novelty Works, El Paso, Texas, makes a strainer almost identical with the one described above. The El Paso Foundry and Machine Co., El Paso, Texas, also makes a strainer of this type but with some difference in detail.

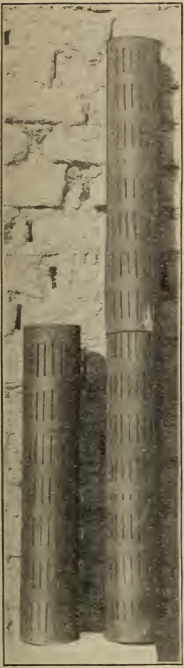

Fig. 12½. A home made six-inch slotted strainer. made and used by J. S. Porcher, El Paso, Texas.

Fig. 12½ illustrates a home made strainer, made and used by Mr. J. S. Porcher, El Paso, Texas.

Placing the Strainer

The success of the well may depend upon the proper location of the strainer in the gravel stratum. If the stratum consists of pure gravel the top of the strainer may be placed about one foot below the top of the gravel stratum but in cases where 20 per cent. to 50 per cent. of sand is intermixed with the gravel the top of the strainer should be placed not less than four feet below the top of the gravel stratum. This is necessary for the reason that since the slots of the strainer are ¼ inch wide all the sand surrounding the strainer will enter the well and be pumped out with the water, and the gravel, which is held back by the strainer, will settle to take the place of the sand removed. If the top of the strainer were placed at the top, or near the top, of the gravel stratum it will be readily seen that when the gravel settles after the sand has been removed, the top of the gravel stratum will be considerably below the top of the strainer and therefore, a portion of the strainer would be surrounded by pure sand. This would mean that the sand around this portion of the strainer would constantly be coming into the well and eventually enough sand would be removed so that caving would finally extend to the surface.

A remedy for this would be to throw gravel into the caving portion around the pipe. This would gradually settle and form a slight obstruction to the sand but of course the area of water bearing gravel would be proportionately reduced.

Flushing

By flushing out the well we mean the pumping out of the well to its limit of capacity in order to remove the sand intermingled with the gravel around the strainer. It is somewhat doubtful whether a well under our conditions can be so thoroughly flushed out that no more sand will appear in the water.

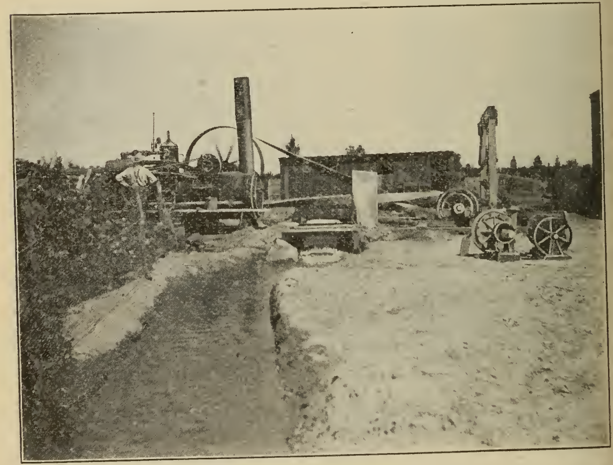

Figure 13. The Station experimental well, pump and engine in use.

The necessity for flushing at all depends entirely upon the type of pump to be used later for pumping. Flushing is extremely desirable if a piston pump is to be used or any other type of pump having close fitting wearing parts. If a centrifugal pump or similar type is to be installed it is not necessary to go to the trouble or expense of flushing the well. Such a pump will not be injured perceptibly by the sand and it will do its own flushing, gradually removing the sand and thus leaving a porous gravel stratum around the strainer through which the water can find its way into the well freely.

Analyses of Water

Parts per 100,000.

	Station Well.	Rio Grande Water from Acequia.	Pecos River.
Suspended matter	——	831.4	179.6
Total solids	104.00	44.11	312.59
Lime, CaO	25.30	8.26	53.28
Magnesia, MgO	5.65	1.36	17.08
Soda, Na_2O	18.38	7.76	53.55
Potash, K_2O	2.13	0.94	2.65
Iron and aluminum, Fe_2O_3 Al_2O_3	0.00	1.85	0.93
Silica, SiO_2	2.50	......	......
Sulfates, SO_3	2.11	10.42	103.26
Chlorids, Cl	15.33	5.41	63.94
Carbonates, CO_2	9.90	5.06	3.19
Crystal water	26.16	4.27	29.16
Total	107.46	45.33	327.04
Oxygen equivalent of Cl (deduct)	3.46	1.22	14.45
Corrected total or total solids	104.00	44.11	312.59

Cost of Station Well

The cost of the experimental well on the Station farm, including curb, pipe, strainer, and sinking did not exceed $150.

POWER

The question of the most economical power is of course a very important one in connection with the matter of installing a pumping plant. A brief discussion of this matter may therefore be of interest.

Wind and water constitute two of the cheapest sources of power. The use of the first of these does not appear to have been productive of very successful results in this territory.

To begin with, the greatest wind movement during the year is in the spring season when, as a rule, water from wells is least needed. In those parts of the territory relying upon river water this source seldom runs short until the spring season is well passed and in these localities pumping for irrigation is not likely to be much resorted to at that time. During the summer months when the greatest need for water for irrigation purposes exists, there is much less wind movement than earlier in the year and it frequently happens that when the water is most needed there is the least amount of wind. The use of storage reservoirs to make more available the water pumped by wind power is open to the criticism of expense for the installation of such reservoirs, together with the high loss through evaporation if the reservoirs are open.

Water as a source of power is available in comparatively few parts of our territory. The question of developing power from our water courses and transmitting it by electricity to the locality where it is most needed has received some attention in the territory and may be of some use in connection with pumping plants for irrigation purposes.

Among the remaining sources of power are steam; oil, including gasoline. kerosene and crude oil; and horse power. The statistics shown in Table 11 will be of interest in a comparison of steam and oil on a basis of economy. The question of which is the most economical fuel must depend largely upon the conditions existing in each locality. In many parts of our territory wood and coal may be procured at relatively so low a cost that steam becomes by far the cheapest available power. It should be borne in mind in this connection that under average conditions a steam engine requires skilled labor to operate it, but, on the other hand, is considered one of the most reliable means of power and the least subject to breakdowns or getting out of order. Gasoline heretofore has cost so much that the question of whether or not it will pay to use it at the present price for developing power for irrigation plants is still a debatable one. On the other hand it will be noticed by looking at Table 11 that the majority of oil engines are operated by common and not skilled labor.

Crude oil as a means of power is being successfully used in various parts of the country. Mr. J. A. Smith, of El Paso, Texas, has recently installed a 28 horse power, Fairbanks-Morse, crude oil engine which, although at the time these lines are written, has not been running for any length of time, is giving entirely successful results. An important consideration in the use of crude oil is the tendency that appears to exist of increased price of the oil. During the past six months the price of crude oil in the vicinity of El Paso has steadily advanced and a number of users of crude oil in that city have recently discarded it in favor of other fuel. The manager of the El Paso Water Works, under date of Feb. 18th, writes in this connection as follows:

"The price of Beaumont oil has gone to $1.21 per barrel, El Paso delivery. This is equal to coal at $4.84 per ton and we can get coal at $4.50, so you see oil burning in El Paso and vicinity is a thing of the past. We have half our furnaces changed to coal now."

It is thus evident that, before installing a pumping plant, the owner should carefully investigate the cost of available fuel, including, of course, delivery charges on oil, coal, and wood. It is suggested in this connection that the reader consult the data shown in Table No. 11.

PUMPS

Various Types and Relative Efficiency

"There are four distinct types of pumps—the plunger or piston pump, ****; the vacuum, the rotary, and the centrifugal, besides elevators which raise water by means of flights attached to an endless chain."* Probably only the three last named types can be relied upon for cheap production of large quantities of water for irrigation by pumping. It is not the purpose of the writers, however, to enter into a lengthy discussion of the relative efficiency of the various types of pumps other than those under the test.

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* Wilcox, Irrigation Farming, p. 251.

For our present purpose the efficiency of the pumps is reckoned upon the relative cost of lifting a given amount of water from the same well.

Centrifugal pumps having no close-fitting or complicated working parts, create comparatively little friction, are seldom or never out of order, and are not appreciably injured by sand or gravel in the water, yet in this type of pump there is a considerable loss of power by the slippage or play of the water upon the loosely fitting paddles.

Rotary pumps have closs-fitting working parts, which may or may not be of a complicated nature, with a relative increase in friction, and in the latter case are more difficult to keep in repair. But on the other hand the suction is positive and there is almost no loss of power by slippage of water upon the paddles, and thus result in a greatly increased efficiency. Sand must not exist in the water unless there is some method of taking up the wear upon the working parts.

We are unable, at this time, to pass upon the durability of the pumps tested more than what may be said from the working of the pumps and from their individual appearance. There is little question as to the durability of centrifugal pumps. As to the rotary, with its cams and rollers to operate the pistons and springs to take up the wear, caused by sand, etc., to say the least, it will require greater intelligence and care in operating.

PUMPS TESTED BY THE STATION

Conditions of the Test

The pumps were tested practically under like conditions, namely; upon the same well; placed the same distance from the water level in so far as the form of the pumps would permit; with the same engine, a 20 H. P. steam engine and boiler (except where otherwise specified) with the same kind and amount of wood by weight, namely, one quarter of a cord, weighing 492 pounds, of small dry tornillo wood; under the same steam pressure, with a few necessary exceptions where the work was heavy; with the water level in the boiler practically the same: and with the same weir and apparatus for measuring the water discharged by the pumps.

Results Secured From Pumps Tested

(1) *Van Wie Centrifugal Pump*

The Van Wie Centrifugal Pump, illustrated in Figs. 14 and 15, is of the vertical single top side suction, belted type, made by the Baldwinsville Centrifugal Pump Works, Syracuse, N. Y. A No. 5 pump with a 6 inch suction and a 5 inch

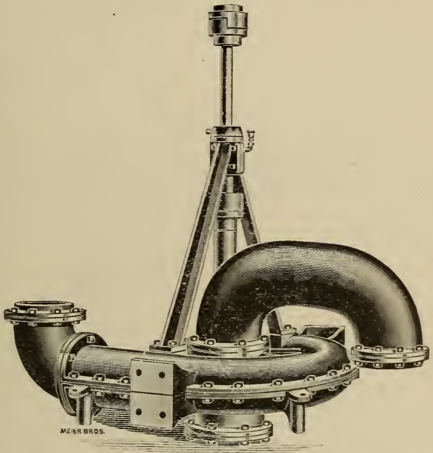

Fig. 14. Exterior view Van Wie Centrifugal Pump, vertical single top side suction type.

discharge, fitted with a six-inch suction and 7 inch discharge pipes, was tested.

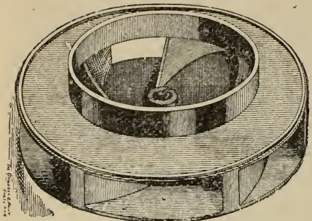

Fig. 15. Showing the Enclosed Piston used in the Van Wie Centrifugal Pump shown in Fig. 14.

Figure 16 shows the manner in which this and the Kingsford, both vertical pumps, were belted to the engine by the use of an idler.

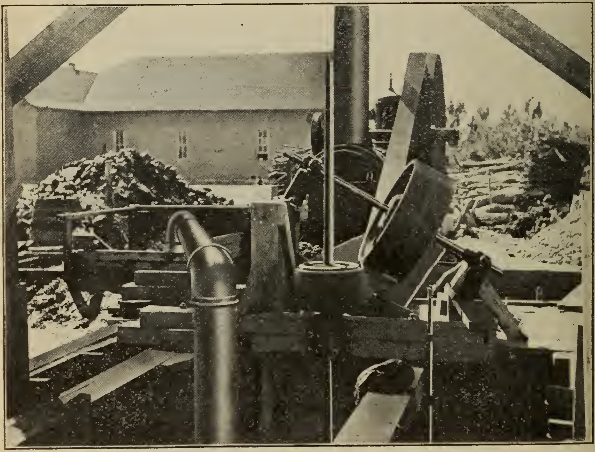

Fig 16. Showing the use of an Idler in belting a Vertical Pump to the Engine.

Figure 17 shows the discharge thrown from a 7 inch pipe by this pump, running at a speed of about 750 revolutions per minute.

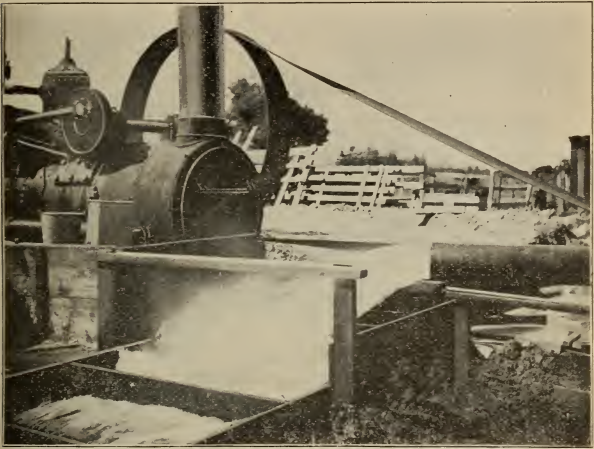

Fig. 17. Discharge thrown from a seven-inch pipe by the Van Wie No. 5 Centrifugal Pump, running at a speed of about 750 revolutions per minute.

The results of the test are recorded in the following table:

Gallons per minute	Speed of Pump, Revolutions per Minute	Time run on ¼ Cord Wood (492 lbs)			
600	455	2	hours.	29	min.
824	515	1	"	43	"
944	530	1	"	29	"
988	540	1	"	14	"
997	760				

(2) *R. D. Wood Co's Centrifugal Pump*

The R. D. Wood Co's. Centrifugal Pump, illustrated in Figs. 18 and 19, is of the horizontal, double side suction, belted type, made by R. D. Wood & Co., Philadelphia, Pa. A No. 6 pump with a 6 inch suction and 6 inch discharge, fitted with 6 inch suction and 6 inch discharge pipes, was tested. Figure 20 shows the discharge from a 6 inch pipe thrown by this pump at a speed of about 900 rev. per min.

The results of the test are given below:

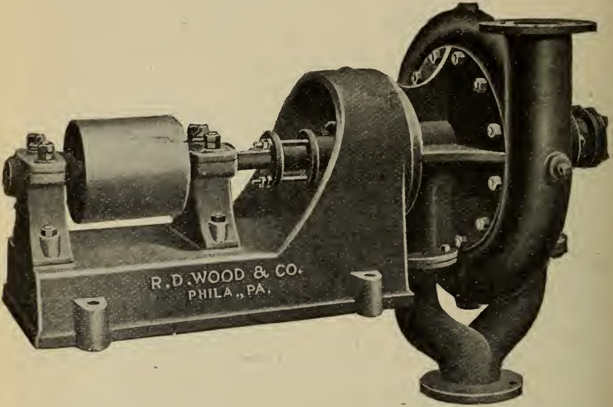

Fig. 18. Exterior view R. D. Wood Co's. Centrifugal Pump, double side suction type.

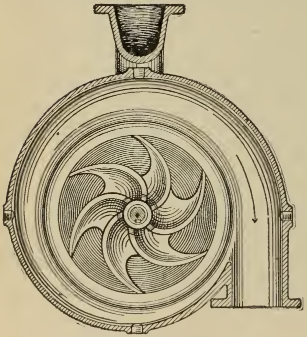

Fig. 19. Interior view of the R. D. Wood Co's Pump illustrated in Fig. 18.

The results of the test are given below:

Gallons per Minute	Speed of Pump Revolutions per Minute	Time run on ¼ Cord Wood (492 lbs.)
600	695	1 hr., 58 min.
824	797	1 hr., 23 min.
944	900	1 hr., 9 min.

This pump was tested first and again after two others as a check.

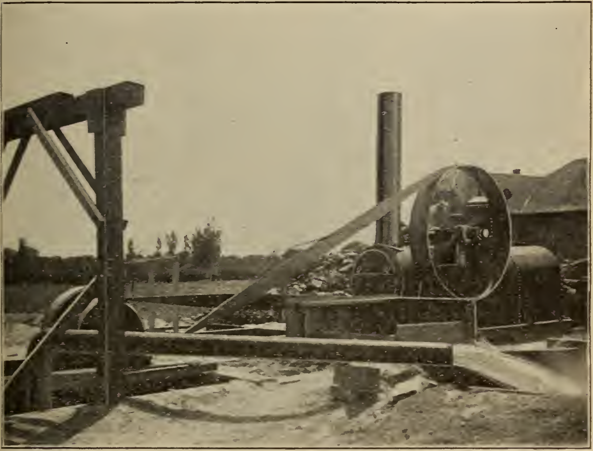

Fig. 20. Discharge thrown from a six-inch pipe by the R. D. Wood Co's. No. 6 Pump running at a speed of about 900 revolutions per Minute.

(3.) *Kingsford Centrifugal Pump*

The Kingsford Centrifugal Pump, illustrated in Figure 21, is of the vertical single bottom side suction, belted type, made by the Kingsford Foundry and Machine works, Oswego, N. Y. A No. 6 pump with a 7 inch suction and a 6 inch discharge, fitted with 7 inch suction and 6 inch discharge pipes, was tested. Figure 22 shows the discharge from a 6 inch pipe thrown by this pump running at a speed of about 640 revolutions per minute.

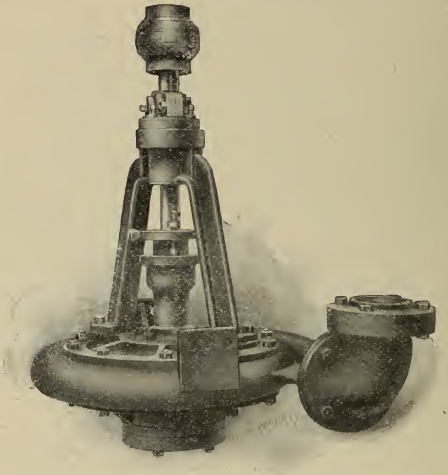

Fig. 21. Kingsford Centrifugal Pump, Vertical single bottom side suction type.

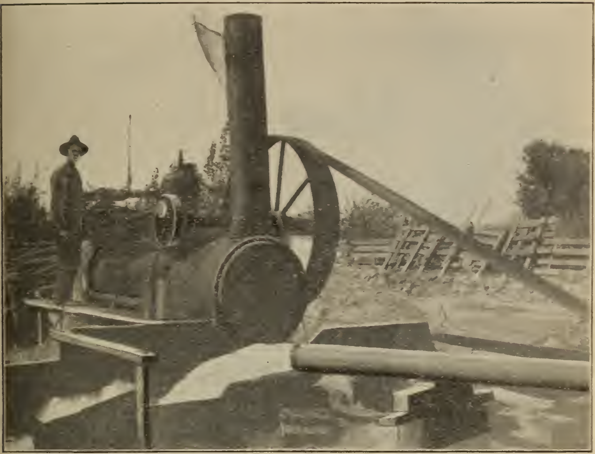

Fig. 22. Discharge thrown from a six-inch pipe by the Kingsford Centrifugal Pump No. 6, running at a speed of about 640 revolutions per minute.

The results of the test are recorded below:

Gallons per Minute	Speed of Pump Revolutions per Minute	Time run on ¼ Cord Wood (492 lbs.)
600	415	2 hr., 4 min.
824	450	1 hr., 33 min.
944	505	1 hr., 18 min.
988	600	0 hr., 51 min.
1000	640	

(4.) *Byron-Jackson Centrifugal Pump*

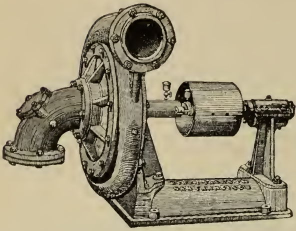

Fig. 23. Exterior view of Byron-Jackson Centrifugal Pump, horizontal single side suction type.

The Byron-Jackson centrifugal pump, illustrated in Figure 23 is of the horizontal, single side suction, belted type, made by the Byron Jackson Machine Works, 411 Market St., San Francisco, Cal. A No. 6 pump with 6 inch suction and discharge, fitted with 8 inch suction and discharge pipes was tested. Figure 24 shows the discharge thrown by this pump from an 8 inch pipe,—about 1000 gallons per minute.

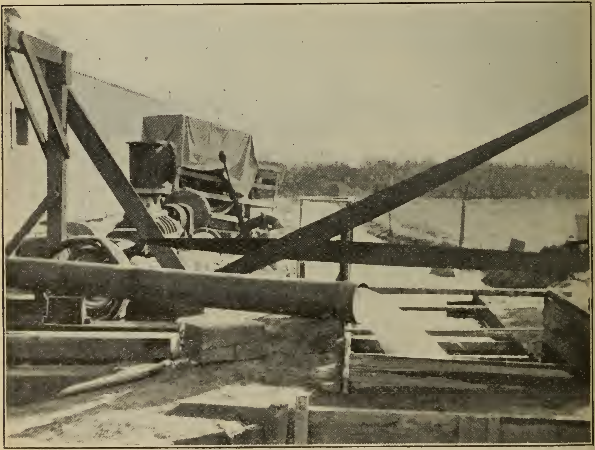

Fig. 24. Discharge of about 1,000 gallons a minute thrown from an eight-inch pipe by the Byron Jackson Centrifugal Pump No. 6.

The results of the test are recorded in the following table.

Gallons per Minute	Speed of Pump Revolutions per Minute	Time run on $\frac{1}{4}$ cord wood (472 lbs)
600	570	1 hour 46 min.
824	650	1 hour 24 min.
944	700	1 hour 19 min.
988	730	1 hour 15 min.
1028	790	

(5) *Fairbanks-Morse Centrifugal Pump*

The Fairbanks-Morse centrifugal pump, illustrated in Figure 25, is of the horizontal, double side suction belted type, made by Fairbanks, Morse and Company, Chicago, Ill.

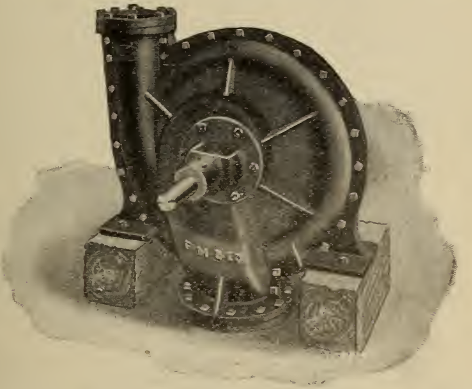

Fig. 25. Fairbanks-Morse Centrifugal Pump; horizontal double side suction type.

A No 6 pump with an 8 inch suction and a 6 inch discharge, fitted with 8 inch suction and discharge pipes, was tested. The discharge thrown by this pump is practically the same as shown in Figure 24.

The results of the test are recorded in the following table:

Gallons per minute	Speed of Pump Revolutions per Minute	Time run on $\frac{1}{4}$ cord wood (492 lbs)
600	448	1 hour 53 min.
824	517	1 " 30 "
944	528	1 " 14 "
988	545	1 " 6 "
1085	680	

(6) *Roots' Rotary Pump*

In accordance with the invitation extended by the Station to the leading pump manufacturers of the country, the P. H. and F. M Roots Co., of Connersville, Indiana, sent to the station one of their rotary pumps with 16 inch suction and 14 inch discharge. Some trouble was experienced in securing satisfactory results in the operation of this pump, which was placed at the surface of the ground, in accordance with the instructions of the manufacturers, and not at the bottom of the open portion of the well, as the other pumps were placed. The pump will be tested under different conditions later and the results announced, but in the meantime, and until it is felt that the pump has been given a proper test, it is deemed better to give no statement in this bulletin of the results obtained.

Tests with Smaller Pumps

These tests were run with a 12 horse power engine and first class tornillo wood.

(1) *Byron-Jackson Pump*

A test was also made with a Byron-Jackson pump, No. 4, made by the same firm as the No. 6, with a 4 inch suction and a 4 inch discharge, fitted with 4 inch suction and 5 inch discharge pipes. (See Table No. 2.)

Figure No. 26 shows the discharge thrown from this pump from a 5 inch pipe, about 500 gallons per minute.

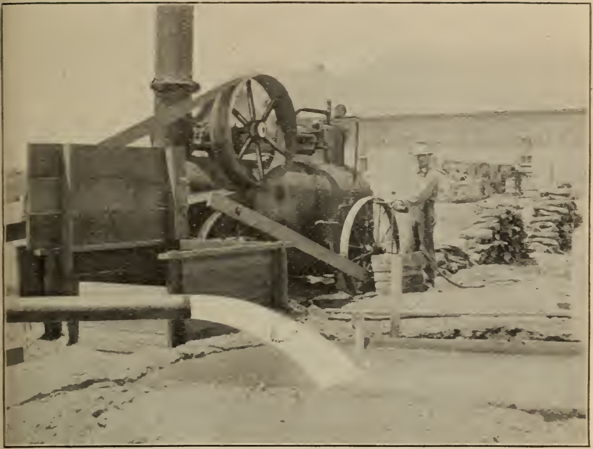

Fig. 26. Discharge of about 500 gallons per minute thrown from a five-inch pipe by a Byron-Jackson No. 4 Centrifugal Pump.

The results of the test are given below:

Gallons per minute	Speed of Pump Revolutions per Minute	Time run on $\frac{1}{4}$ cord wood
378	700	3 hrs., 00 Min.
487	800	1 " 15 "

Johnson Rotary Pump

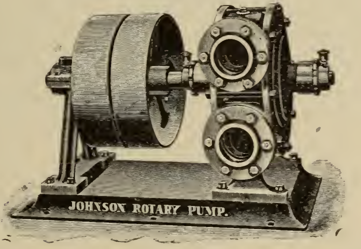
JOHNSON ROTARY PUMP.

Fig. 27. Exterior view of Johnson Rotary Pump: front single suction type.

The Johnson Rotary Pump, illustrated in Figures 27 and 28, is of the front, single suction, belted type, made by the Davis, Johnson Co., 41 West Randolph St., Chicago, Ill. A No. 5 pump, fitted with 5 inch suction and 5 inch discharge pipes, was tested. Figure 29 illustrates the discharge thrown by this pump from a 5 inch pipe, 330 gallons per minute.

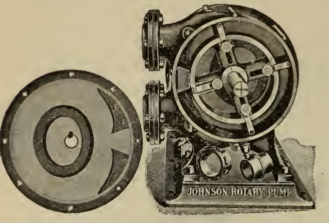

Fig. 28. Interior view of Johnson Rotary Pump shown in Fig. 27.

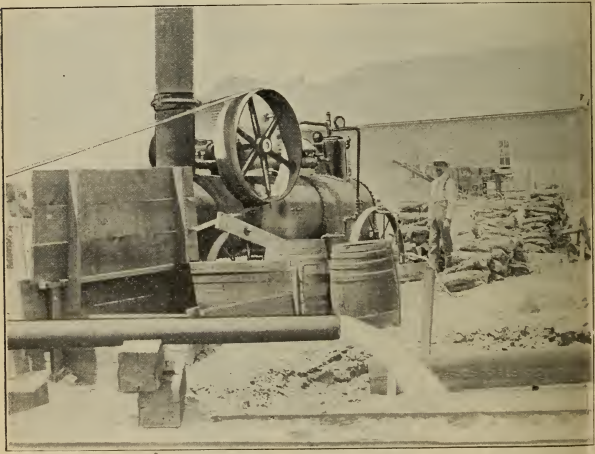

Fig. 29. Discharge of about 330 gallons per minute thrown from a five-inch pipe by Johnson Rotary Pump No. 5.

The results of the test are given below:

Gallons per min.	Speed of Pump Revolutions per min.	Time run on ¼ cord wood.
322	125	4 hrs., 30 min.

This pump was put in a second time, fitting it with 6 inch suction and 6 inch discharge pipes. There was no material change in the results.

COMPARATIVE RESULTS OF PUMPS TESTED

The following tables, Nos. 1 and 2, show the results of the comparative tests made with the foregoing pumps:

Table No. 1.

Comparative Test of Pumps

Showing the relative standing of the pumps tested at different speeds.

Name of Pump.	At 600 Gal. per Min.	At 824 Gal. per Min.	At 944 Gal. per Min.	At 988 Gal. per Min.	At the Most Economic Speed.	Gal. per Min. Most Economic Speed.
Van Wie No. 5	1st	1st	1st	3rd	1st	600
R. D. Wood No. 6	3rd	5th	5th	......	5th	600
Kingsford No. 6	2nd	2nd	3rd	4th	2nd	824
Byron Jackson No. 6	5th	4th	2nd	1st	3rd	944
Fairbanks-Morse No. 6	4th	3rd	4th	2nd	4th	824

Table No. 2.

Relative Economy of Pumps Tested.

Showing for each pump the speed, gallons per minute pumped, and time run on one-quarter cord of small tornillo wood.

Name of Pump	Kind of Pump	Speed of Pump	Gallons per minute	Suction		Discharge		Total Lift		Time run on ¼ cord wood*	
				Feet	Inches	Feet	Inches	Feet	Inches	Hrs.	Mins.
Van Wie No 5	Vertical Centrifugal	455	600	12	6¾	15	3½	27	10¼	2	29
" "	" "	515	824	17	8	15	3½	32	11½	1	43
" "	" "	530	944	21	4¼	15	3½	36	7¾	1	29
" "	" "	540	988	22	2¼	15	3½	37	5¾	1	1
" "	" "	760	997	22	2¼	15	3½	37	5¾	....	
Kingsford No 6	" "	415	600	12	6½	15	6	28	0½	2	4
"	" "	450	824	17	7¾	15	6	33	1¾	1	33
"	" "	505	944	20	5¾	15	6	35	11¾	1	18
"	" "	600	988	21	0½	15	6	36	6½	0	51
"	" "	640	1000	22	2	15	6	37	8	....	
R. D. Wood No 6	Horizontal "	695	600	14	5½	14	4	28	9½	1	58
" " "	" "	797	824	20	1½	14	4	34	5½	1	23
" " "	" "	900	944	22	4¾	14	4	36	8¾	1	9
Byron Jackson No 6	" "	570	600	12	9¼	15	2	27	11¼	1	46
" "	" "	650	824	19	3¼	15	2	34	5¼	1	24
" "	" "	700	944	21	6½	15	2	36	8½	1	19
" "	" "	730	988	23	9¾	15	2	38	11¾	1	15
" "	" "	790	1028	24	1¼	15	2	39	3¼	....	
Fairbanks-Morse No. 6	" "	448	600	13	8¼	15	3	28	11¼	1	53
" "	" "	517	824	20	5¾	15	3	35	8¾	1	30
" "	" "	528	944	21	10¾	15	3	37	1¾	1	14
" "	" "	545	988	23	0½	15	3	38	3½	1	6
" "	" "	680	1085	26	8½	15	3	41	11½	....	
†Byron-Jackson No. 4	" "	700	378	16	1¼	15	0½	31	1¾	3	00†
†Johnson Rotary No. 5	" Rotary	125	322	9	8¼	14	6½	24	2¾	4	30†

*One cord of tornillo wood weighed 1,968 pounds, one-quarter cord 492 pounds.

†These pumps were tested with a 12 H. P. steam engine, and with large tornillo wood.

COST OF IRRIGATING BY PUMPING

In order to aid in the calculation, by those interested, of the probable cost of irrigating from wells by means of pumps, the series of tables which follow have been compiled. The information given in these tables is based upon the experimental work that has been done by the Station, as already set forth. It is well known that for short runs the expenses are proportionately higher than for long continued runs with plants of this kind, and it is, therefore, safe to say that the figures shown in these tables are an outside limit of the cost of irrigating for any continuous length of time under conditions similar to those which governed the work conducted by the Station.

The tables shown herewith are as follows:

List of Tables on Cost of Pumping

Table No. 3. Comparative cost of fuel for pumps tested.
Table No. 4. Duty of fuel with pumps tested.
Table No. 5. Comparative cost of a three inch irrigation.
Table No. 6. Comparative test of fuel.
Table No. 7. Acres irrigated by varying quantities of water.
Table No. 8. Size of farm irrigated by varying quantities of water.

Table No. 3.

Comparative Cost of Fuel for Pumps Tested.

Showing the quantity and cost of fuel used by the different pumps tested, pumping at different speeds and for runs of 10 and 24 hours.

Name of Pump.	Pumping 600 Gal. per Minute.				Pumping 824 Gal. per Minute.				Pumping 944 Gal. per Minute.				Pumping 988 Gal. per Min.			
	Cords Wood used in 10 Hrs.	Cords Wood used in 24 Hrs.	Cost of fuel for 10 Hrs. Run.	Cost of fuel for 24 Hrs. Run	Cords Wood used in 10 Hrs.	Cords Wood used in 24 Hrs.	Cost of fuel for 10 Hrs. Run.	Cost of fuel for 24 Hrs Run.	Cords Wood used in 10 Hrs.	Cords Wood used in 24 Hrs.	Cost of fuel for 10 Hrs. Run.	Cost of fuel for 24 Hrs. Run.	Cords of Wood used in 10 Hrs	Cords Wood used in 24 Hrs.	Cost of fuel for 10 Hrs. Run.	Cost of fuel for 24 Hrs. Run.
Van Wie....................	1.006	2.416	$2 26	$5 44	1.456	3.495	$3 28	$7 86	1.685	4.044	$3 79	$9 10	2.459	5.901	$5 53	$13 28
Kingstord....................	1.209	2.903	2 72	6 53	1.612	3.870	3 63	8 71	1.923	4.615	4 33	10 38	2.941	7.058	6 62	15 88
R. D. Wood..................	1.271	3.05	2 86	6 86	1.807	4.337	4 07	9 76	2.173	5.217	4 89	11 74	....	....	....	....
Byron Jackson.....	1.415	3.396	3 18	7 64	1.785	4.285	4 02	9 64	1.898	4.556	4 27	10 25	2.000	4.800	4 50	10 80
Fairbanks-Morse............	1.327	3.185	2 99	7 17	1.666	4.000	3 75	9 00	2.027	4.864	4 56	10 94	2.272	5.454	5 11	12 27

NOTE. The above tests were run with small dry tornillo wood as fuel, costing $2.25 per cord.

Table No. 4.

Duty of Fuel with the Pumps Tested.

Showing the number of gallons pumped by one cord and one ton dry tornillo wood at the different speeds and at the most economic speed for each pump.

Name of pump.	600 Gals. per min.		824 Gals. per min.		944 Gals. per min.		988 Gals. per min.		At most economic speed.		Gallons per minute at most economic speed.
	1 cord	1 ton	1 cord	1 ton	1 cord	1 ton	1 cord	1 ton	1 cord	1 ton	
Van Wie	357600	363414	339488	345008	336064	341528	241072	244991	357600	363414	600
R. D. Wood	283200	287804	273568	278016	260544	264780	....	....	283200	287804	600
Kingsford	297600	302439	306528	311512	294528	299317	201552	204829	306528	311512	824
Byron Jackson	254400	258536	276864	281365	298304	303154	296400	301219	298304	303154	944
Fairbanks-Morse	271200	275609	296640	301463	279424	283967	260832	265073	296640	301463	824

Table No. 5.

Comparative Cost of a Three-inch Irrigation.

Showing the cost of fuel per acre for irrigating three inches deep using dry tornillo wood at $2.25 per cord.

Name of Pump.	At most economic speed.	At 600 gallons per minute.	At 824 gallons per minute.	At 944 gallons per minute.	At 988 gallons per minute.
Van Wie	$ .512	$ .512	$ .539	$ .545	$ .760
R. D. Wood	.647	.647	.669	.703	....
Kingsford	.597	.615	.597	.622	.909
Byron Jackson	.614	.720	.661	.614	.618
Fairbanks-Morse	.617	.675	.617	.655	.702

Table No. 6.

Comparative Test of Fuel.

Showing the number of gallons pumped with one cord and one ton of fuel, using three kinds of wood and coal.

Kind of Fuel,	Weight of one cord. Pounds.	Hours one cord ran 824 Gal. per min.	Hours one ton ran 824 Gal. per min.	Cost of one cord.	Cost of one ton.	Gallons one cord Pumped	Gallons one ton Pumped.	Cost of Pumping 100,000 Gal.
Medium Cottonwood	2218	5 hr. 49 m.	5 hr. 14 m.	$2 00	$1 80	287576	258736	$ .70
Small Tornillo	1968	6 hr. 0 m.	6 hr. 5 m	2 25	2 29	296640	300760	.76
Large “	2830	8 hr. 0 m	5 hr. 39 m.	2 50	1 76	395520	279336	.63
Coal (Gallup)	......	....	9 hr. 24 m.	......	6 00	....	464736	1.29

NOTE. The above test was run with the R. D. Wood & Co. Horizontal Centrifugal Pump.

Table No. 7.

Acres Irrigated by Varying Quantities of Water.

Showing the number of acres irrigated in 1,10 and 24 hours, pumping various quantities, and irrigating various depths.

Gallons pumped per minute.	Acres irrigated in one hour.						Acres irrigated in 10 hours.						Acres irrigated in 24 hours.					
	1 in deep	2 in deep	3 in deep	4 in deep	5 in deep	6 in deep	1 in deep	2 in deep	3 in deep	4 in deep	5 in deep	6 in deep	1 in deep	2 in deep	3 in deep	4 in deep	5 in deep	6 in deep
600	1.3	.6	.4	.3	.2	.2	13.2	6.6	4.4	3.3	2.6	2.2	31.8	15.9	10.6	7.9	6.3	5.3
824	1.8	.9	.6	.4	.3	.3	18.2	9.1	6.0	4.5	3.6	3.0	43.7	21.8	14.5	10.9	8.7	7.3
944	2.1	1.0	.7	.5	.4	.3	20.8	10.4	6.9	5.2	4.1	3.4	50.0	25.0	16.7	12.5	10.0	8.3
988	2.2	1.1	.7	.5	.4	.3	21.8	10.9	7.2	5.4	4.3	3.6	52.4	26.2	17.4	13.1	10.4	8.7
1000	2.2	1.1	.7	.5	.4	.3	22.1	11.0	7.3	5.5	4.4	3.7	53.0	26.5	17.6	13.2	10.6	8.8
1200	2.6	1.3	.9	.6	.5	.4	26.5	13.2	8.8	6.6	5.3	4.4	63.6	31.8	21.2	15.9	12.7	10.6
1500	3.3	1.6	1.1	.8	.6	.5	33.1	16.5	11.0	8.2	6.6	5.5	79.5	39.7	26.5	19.9	15.9	13.2
2000	4.4	2.2	1.4	1.1	.9	.7	44.2	22.1	14.7	11.0	8.8	7.3	106.0	53.0	35.3	20.5	21.2	17.6

Note—In the above computation all fractions below .08 have been dropped.

Table No. 8.

Size of Farm Irrigated by Varying Quantities of Water.

Showing the acreage of land that can be irrigated by a given quantity of water (from 600 to 2,000 gallons per minute), pumping 10 or 24 hours a day, and irrigating every 10, 14, 21 or 30 days.

Gallons Per Minute.	Number Hours Run.	Irrigated Every 10 Days.						Irrigated Every 14 Days.						Irrigated Every 21 days.						Irrigated Every 30 Days,					
		1 inch deep.	2 inches deep.	3 inches deep.	4 inches deep.	5 inches deep.	6 inches deep.	1 inch deep.	2 inches deep.	3 inches deep.	4 inches deep.	5 inches deep.	6 inches deep.	1 inch deep.	2 inches deep.	3 inches deep.	4 inches deep.	5 inches deep.	6 inches deep.	1 inch deep.	2 inches deep.	3 inches deep.	4 inches deep.	5 inches deep.	6 inches deep.
600	10	132	66	44	33	26	22	185	92	61	46	37	31	277	138	92	69	55	46	396	198	132	99	79	66
	24	318	159	106	79	63	53	445	222	148	111	89	74	668	334	222	167	133	111	954	477	318	238	191	159
824	10	182	91	60	45	36	30	255	127	85	63	51	42	382	191	127	95	76	63	546	273	182	136	109	91
	24	437	218	145	109	87	73	611	305	204	153	122	102	917	458	305	229	183	153	1311	655	437	327	262	218
944	10	208	104	69	52	41	34	291	145	97	72	58	48	437	218	145	109	87	73	624	312	208	156	125	104
	24	500	250	167	125	100	83	700	350	233	175	140	116	1050	525	350	262	210	175	1500	750	500	375	300	250
988	10	218	109	72	54	43	36	305	152	101	76	61	51	458	229	152	114	91	76	654	327	218	163	131	109
	24	524	262	174	131	104	87	733	366	244	183	146	122	1100	550	366	275	220	183	1572	786	524	393	314	262
1000	10	221	110	73	55	44	37	309	154	103	77	62	51	464	232	154	116	93	77	663	331	221	165	132	110
	24	530	265	176	132	106	88	742	371	247	185	148	123	1113	556	371	278	222	185	1590	795	530	397	318	265
1200	10	265	132	88	66	53	44	371	185	123	92	74	62	556	278	185	139	111	92	795	397	265	198	159	132
	24	636	318	212	159	127	106	890	445	297	222	178	148	1335	668	445	334	267	222	1908	954	636	477	381	318
1500	10	331	165	110	82	66	55	463	231	154	116	92	77	695	347	231	173	139	116	993	496	331	248	198	165
	24	795	397	265	198	159	132	1113	556	371	278	222	185	1669	834	556	417	334	278	2385	1193	795	596	477	397
2000	10	442	221	147	110	88	73	618	309	206	154	123	103	928	464	309	232	185	154	1325	662	441	331	265	221
	24	1060	530	353	265	212	176	1484	742	495	371	297	247	2226	1113	742	556	445	371	3180	1590	1060	795	636	530

NOTE. In the above computations all fractions below .8 have been dropped.

PUMPING PLANTS IN NEW MEXICO

Comparatively little has been done in New Mexico in the way of irrigating lands from wells by means of pumping plants. The statistics for the census of 1900 show that only 1,004 acres of land in New Mexico are irrigated from wells as against nearly 203,000 acres which are irrigated from streams. The irrigation from wells so far practiced in New Mexico has been confined to the few farmers who have practiced irrigation in this manner from small plants when they have had no other source of water or as a means of supplementing the regular supply when the latter fails, and in most of these cases the plants have been operated by wind-mills. The practice of irrigating from wells is in its infancy in our territory and the possibilities of the work appear not yet to have been generally recognized by our citizens

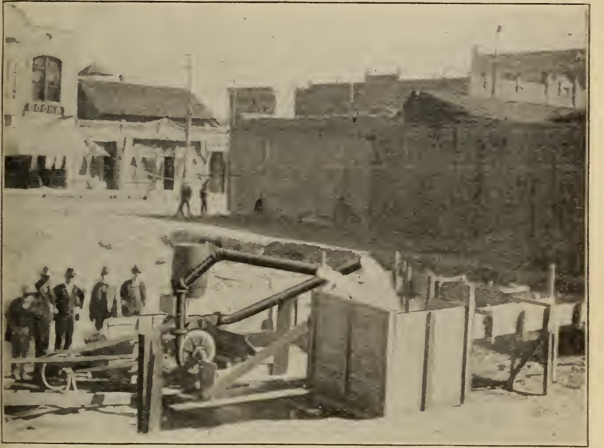

Fig. 30. Competitive Test of Pumps at the El Paso, (Texas) Carnival January 18, 1902. Water pumped from Open Tank, with lift of nine feet. Slanting pipe from six-inch Johnson Rotary Pump discharging 700 gallons per minute; horizontal pipe from six-inch Byron-Jackson Centrifugal Pump discharging 800 gallons per minute.

Although not in New Mexico, the conditions existing near El Paso, which is less than than thirty miles from the southern border of our territory, deserve some notice. The experience of the farmers in that region is of some value. Through a constant fuilure of the regular supply of the irrigating water from the Rio Grande the farmers of that locality have been compelled to turn their attention to other water supplies or else abandon all agricultural work. As a consequence they have demonstrated the fact that crops can be profitably grown by irrigation from wells tapping the underflow in the Rio Grande Valley. Some of these plants have been in operation for several years past and by statistics secured it is shown that the work is a profitable one. The conditions there are almost exactly similar to those prevailing over a

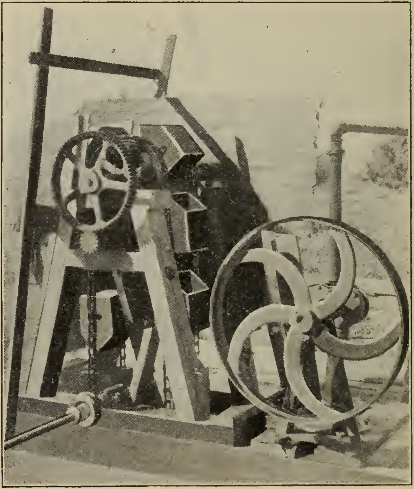

Fig. 31. A Gould's Endless Chain Bucket Pump used by Mann Bros. of Albuquerque for Irrigating.

large part of the Rio Grande Valley and it is largely because the river water has failed in that region that the work of irrigating by means of pumps has been more fully developed than throughout the Rio Grande Valley generally of New Mexico.

The tables presented herewith upon the wells and pumping plants of New Mexico and the Rio Grande Valley show comparative statistics which have been secured by personal investigation and by extensive correspondence with the owners of such plants. Some of the most valuable data received regarding wells in New Mexico have been gained through the experience of the Santa Fe Railway Company in sinking wells for the necessary water supply along its line in our territory and a separate table is made on this subject. (See Table 13.) The tables show, further, the comparative conditions existing in our territory and in other regions from which data have been secured.

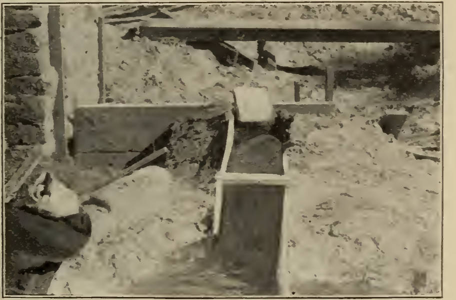

Fig. 32. Discharge of about 450 gallons per minute through a six-inch pipe from pump of J. Stoney Porcher, El Paso, Texas.

PUMPING PLANTS IN OTHER STATES

For the purpose of presenting comparative data in this bulletin a systematic correspondence has been conducted by means of which statistics concerning pumping plants in other parts of the United States have been secured. In gathering and compiling these statistics, representative cases so far as possible have been taken and the reader is thus enabled to compare in the same table relative figures as to the cost and the utility of plants as they exist in various regions.

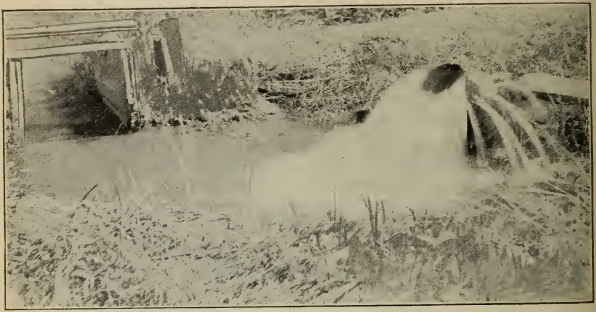

Fig. 33. Discharge of about 300 gallons per minute through a six-inch pipe from pump of E. J. Hadlock, El Paso, Texas.

California leads all other states in the number of acres irrigated from wells. The last census shows that a total of 152,506 acres of land were in 1899, irrigated from wells, or more than ten per cent of the total acreage irrigated in that state. Colorado comes next with a much lower percentage, 7,050 acres, irrigated from wells. From these two states representative cases have been used in the compilation of the tables presented herewith. In Lousiana and East Texas the recent development of the rice industry has been the reason for the irrigation of enormous tracts of land by pumping plants. Most of these are operated on very low lifts from beds of water under different conditions from those which must prevail in our territory. Through the higher lands, however, pumping is practiced for the irrigation of rice and other crops from deep wells and a few instances of this kind have been compiled in the tables shown.

RELATIVE CONDITIONS IN THE RIO GRANDE VALLEY

It may not be amiss in this bulletin to call attention to the conditions in the Rio Grande valley for pumping for irrigation as they compare with other states and regions. In the pumping of water for irrigation the most important consideration is a large available amount of water at a reasonable depth. From this standpoint alone it becomes apparent to the person who gives any thought to the matter of comparative conditions that hardly any, if any, other locality can show better advantages than the Rio Grande valley. Water throughout the valley in large quantities may be secured any where below a depth of from 15 to 20 feet, and the whole valley appears to be underlaid by, so far as we know, an almost inexhaustible supply of water. This water is of good quality and occurring at so short a distance below the surface of the

Pig. No. 34. Irrigating ditch filled by pump of E. J. Hadlock referred to in Plate 33.

ground may be raised very economically. It appears probable that in almost any part of the valley sufficiently thick beds of water bearing gravel may be met with to allow the placing of a strainer such as that used in the station well. This being so, it makes unnecessary the expensive strainers that are used in some regions to secure water from sand. The cost of the construction of a well need not be heavy. The work of the experiment station appears to have demonstrated the fact that with a well costing from $100 to $200 an ample supply of water may be secured for the irrigation of a farm of 100 acres or more.

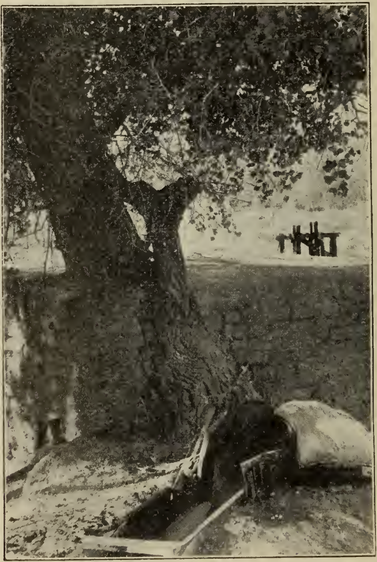

Fig. No. 35. Discharge of about 450 gallons per minute through a seven-inch pipe from pump of Julius T. Porcher, El Paso, Texas.

Probably no part of the country has been more often referred to for successful examples of profitably pumping for irrigation than Southern California. The Rio Grande Valley possesses many advantages which Southern California has not and lacks few that are possessed by the Golden State. Many of the wells from which water is pumped for irrigating purposes in California are several hundred feet deep and sunk at an expense for original cost far greater than is necessary in this valley. Land is many times more expensive in California than here and labor much more costly. The prices received for products are about the same in both California and New Mexico and the matter of markets, with proper development, ought to be extensive enough in this territory to take care of all the products that can be raised. We can, however, learn from the California irrigator the lesson of economical methods and the proper use and duty of water.

A comparison of the conditions existing in the valleys of New Mexico in which irrigation by pumping can be practiced can not but inspire faith in the great possibilities of our territory in any one who will carefully study the question.

The data secured regarding pumping plants in New Mexico and in other states is herewith presented in the following

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LIST OF TABLES CONCERNING PUMPING PLANTS

Table No. 9—Data concerning wells.
Table No. 10—Data concerning pumps.
Table No. 11—Data concerning engines.
Table No. 12—Data concerning lands irrigated from wells.
Table No. 13—Railroad pumping plants in New Mexico.

PUMPING PLANTS AND COOPERATION

Pumping plants resolve themselves into two classes, namely, cooperative and individual plants, in each of which there is much of merit. The former may be defined as a pumping plant from which two or more formers may obtain water, while the latter refers to pumping plants located upon each farm under individual control and supplying individual needs. The moment the control is divided or there is a division of water, however obtained, the plant passes into the cooperative class, though it may be a modified form of cooperation.

A cooperative plant wherever located, for obvious reasons, should render the maximum of efficiency and economy of production. Objections which might justly be made against a large plant located at the head of a ditch are:

1st. The difficulty and great cost of developing water at one place in a sufficiently large quantity.

2nd. Opportunities for misappropriation and waste of water.

3rd. Loss of water by seepage and evaporation.

4th. Making and maintaining a just and equitable division of the water.

The same objections, in a much modified degree, might be raised against plants so placed as to supply only a small number of shareholders. With a few shareholders, however, it would be a much easier task to divide the water properly and there would be far less danger of misappropriation.

Perhaps the strongest objections that can be made against individual plants are: 1st, a relatively large initial cost of installation, and 2nd, a low rate of efficiency and economy. However, the individual pumping plant has advantages that should not be overlooked. They are: 1st, misappropriation of water is impossible. The water is developed upon the farm where it is used and therefore at all times is within the domain and under the control of its owner. 2nd, loss by evaporation and seepage is minimized. 3rd, there is no division of water and, therefore, injustice from a lack of equita-

TABLE NO. 9

Data Concerning Wells

NOTE— In Considering Figures in 15th Column, Regarding Ample Supply of Water for Pump, Refer to Data Concerning Pumps in Table No. 10

Name	Address	Kind of Well	No. of Wells	Diameter	Depth in feet	Depth in Feet to Water Level	Layers of Soil Penetrated	Kind of Soil in Which Well Stops	Cost of Sinking	Kind of Pipe	Cost of Piping per Foot	Kind and Length of Strainer	Cost of Each Strainer	Does Well Supply Ample Water for Pump?	Troubled With Sand in Water?	Kind of Water	Suggested Improvements
I RIO GRANDE VALLEY AND NEW MEXICO																	
(a) Rio Grande Valley																	
Baker F C	Las Cruces, N. M.	Driven	2	4 1-2 ins	30	14	Adobe and gravel	Gravel		Galv. Iron		Cook's Strainer	2 in. $2.50 3 in. $4.00	No	Little	Good	None
Keeler, Herman	Albuquerque, N. M.	Driven	12	8-2 in. 4-3 in.	21	6	Sand and gravel 2 ft. clay at 15 ft.	Gravel & sand	$ 2.00 each	Stand. Blk.	.18	Standard Strainer		No	No		
Cadwallader E F	El Paso, Tex.	Bored	1	6 ins	60	11	Sandy loam and adobe	Gravel	$14.00	Stand. Blk.	.78					Good	Suggests 8-inch well pipe to be drilled with 1-4 holes for point and covered with gauze
Hadlock, E J	El Paso, Tex	Driven	3	4 ins	60	11	Adobe & concrete	Gravel & sand	$25.00	Stand. Blk.	.50	Pipe drilled with ¼ inch round holes 2000 in length of 5 feet	50 c. each 100 holes	Yes	No		None
Howland, A M.	Doña Ana, N. M.	Driven	7	2 and 4 ins.	20			Quicksand				Common 4 feet long				Total solids 74.50 in 100,000	
Howland, A M.	Doña Ana, N. M	Open stone curbing; pipes in bottom of well 1-11 5-8 in. casing 3-6 in. pipes to gravel bed, 30 feet lower	1	18 ft.	33	10				11 5-8 inch casing and 6 in. Stand. Blk.		1-11-5-8 inch casing, and 3-6 inch pipe in bottom of well 30 feet deeper to gravel bed		Yes (a)		Good	
Mann Bros.	Albuquerque, N.M.	Open pipes in bottom of well 3 1-2 in. 3 4 1-2 in. sunk from 30 to 40 ft. lower	4		15	7		Quicksand and gravel	b	Galv. Iron	.38	Perforated 1 inch x 1-8 inch slots entire length of pipes except in clay strata		No	No		Larger and deeper well with more pipes
Porcher J. Stoney	El Paso, Tex.	Bored	1	6 ins	62	12	Sand, adobe and gravel	Gravel & sand	$62 00	Stand. Blk.	.85	Slotted strainer slots 3 inch x 1-8 ins. 12 feet long	$15.00	Yes			None
Porcher, Julius T.	Socorro, Tex.	Bored	2	6 ins	58	13	Sandy loam, quicksand and gravel	Gravel & sand	$15.00 each	Stand. Blk.	.85	Slotted strainer: 10 feet long; slots 3 inch x 1-8 inch; 1 inch apart	$15.00	Yes	Occasionally		None
Smith, J. J.	Ysleta, Tex.	Driven	3	4 ins	58	13	Quicksand & hardpan	Gravel & sand	$ 7 50 each	Casing	.60	Strainer perforated with 1200 5-16 inch holes, length 6 feet	$6.50	No	Occasionally		Suggests 8-foot strainer with 2000 holes
Tibbetts, J	El Paso, Tex.	Bored	2	6 ins.	60	14	Quicksand, gravel and hardpan	Gravel	$60.00 for 1st $35.00 for 2d	Stand. Blk.	$1.05	Sheet steel 1 8 inch thick 10 ft. long, perforated with 5000 3-16 inch round holes	$11.00	Yes	Yes		Would use strainer with 2 inch by 3-16 inch slots instead of holes
(b) Other Points in New Mexico																	
Andrews, Dr. E.	Santa Fé, N. M.	Open	2	3 1-2 and 5 ft	9 and 17		Gravel bed	Gravel bed						No	No	Good	
Rudolph, Brother	Santa Fé, N. M.	Open	1	8 ft.	35	8	Sand and hardpan	Sand and hardpan	$300.00 c					Yes	No	Good	
sum, Wm.	Roswell, N. M.	Bored	1	5 in.	60	27		Sandy	90c. per ft.	Galv. Iron	.75			Yes	No		
Bogle, A P.	Santa Fé, N. M.	Open	1	6 ft.		44	Clay loam, sand and hardpan	Sand and hardpan	$200 c					No d	No	Good	Enlarge capacity of well by drifting and timbering ns in mines
Kerr, T. R.	Cambray, N. M.	Open	5	1-8 ft.; 4-4 ft.	17 to 23	12	Sand concrete & gravel							3 Do	No	Good	
Lee Jesse O.	Roswell, N. M.	Bored	1	5 5-8 in.	34	22	Gypsum, concrete and limestone	Sand & gravel	$1.00 per ft.	Stand. Blk. Inserted casing	.75			Yes	No	Fair	
Smith, P. R	Deming, N. M.	Open	1	18 ft.	55	49	Soil and cement	Gravel between 2 cement stata	$40.00 per ft.					Yes	No	Nearly pure	
Turner, W. P	Roswell, N. M.	Open	1	4 ft.	30	25	Sandy loam, gravel and rock										
(c) Waterworks																	
El Paso Water Co.	El Paso, Tex.	Open	23	1-55 ins. 10-46 ins. 12-38 ins.	35 to 46	22	Sand 12 ft.; coarse and fine gravel 10 ft.; coarse gravel	Coarse gravel	$140.00 each	3 16 sheet steel in 20 sections	$3.25 per ft. for 46 ins. diam.	Some of wells have 10 ft 6 in pipes driven in bottom, perforated with 1-2 in. holes		Yes	No		
El Paso Water Co.	El Paso, Tex.	Driven	23	6 ins.	60	22	Sand 12 ft.: coarse and fine gravel 10 ft ; coarse gravel	Coarse gravel	$85.00 each		.90	Cook's strainers No. 6 slots 10-10 ft., 13-12 ft.		No	No		Would use only open wells
Water Supply Co.	Albuquerque, N M.	Driven	8	2-8 in. 6-6 in.	75	15-20 e				Stand. Blk.		Cook's strainers, 20 ft.		Yes	Very little	Total solids 21.23	
II CALIFORNIA																	
Ellery, F. W.	Pasadena, Cal.	Driven	1	8 1 4 in.	112	35	Sand, gravel and clay	Clay		Double steel casing				Yes	No		None
Medearis Jas. S.	Lamanda, Cal.	Bored	1	7 ins.	197	25	Clay and gravel	Heavy clay	$171.25	16 ga. iron outer and inner	2x26=52c. per ft	Casing slotted according to size of strata and gravel		No	No	Pure	None
Merwin Duncan S.	Pasadena, Cal.	Driven	1	10 ins.	235	65	Sand, gravel and clay	Clay	$385	Steel casing	.86			Yes	No	Soft	None
III COLORADO																	
Behrens, John H.	Evans, Colo.	Open	1	5 ft.	4 f										No	Seepage	
Blandin, O. J.	Eaton, Colo.	Open	1	7 ft.	31	14 3-4	Gravel	Gravel						No	No	Medium hard	Deeper
Brownell, Archie W.	Greeley, Colo.	Open	1	12 ft.	18	13	Clay loam, clay gravel and blue shale	Blue shale						No	Some		
McKenney, Charles	La Salle, Colo.	Open	1	8 ft.	8	2 1-2	Gravel	Gravel				4-10 ft. x 6 in perforated pipes sunk in bottom of well g	$2.50	Yes	No	Alkali	
IV MISCELLANEOUS																	
Ellis, James	Welsh, La.	Bored	1	8 ins.	238	21 1-2 h	Clay, sand and gravel	Gravel	$744 i	Well casing		Casing bored with 150-5-8 in. holes to foot, then wound with No. 16 wire; 66 ft. long.		Yes	Not now	Hard	More and smaller holes in point with coarser winding; deeper sinking into coarser gravel
Green & Snoemaker	Crowley, La.	Bored	3	10 ins	200	3 to 5	Clay, sand and gravel	Coarse sand and gravel	$167.00 each	Well casing	.90	Casing bored with 7-8 in. holes covered with brass gauze and wrapped with wire 1-24 in. between strands: 60 ft. long	$210.00	About 80 per cent.	Slight	Fair	Gauze on points is too fine

a. For pump throwing 1,200 gallons per minute.
b. $5.00 for each of four pipes.
c. Including cost of curbing and all material.
d. Dry in two hours, pumping 60 gallons per minute: refills in two hours.
e. Depending upon "wet" or "dry" season.
f. Seepage ditch runs into well.
g. These four points "more than doubled capacity of well."
h. "8 feet at first: sunk to 21 1-2 feet."
i Including cost of pipe and point.

TABLE No. 10.

Data Concerning Pumps.

Name.	Address	Manufacturer and Kind of Pump.	Cost	Cost of Placing.	Horse Power Required.	No. Strokes or Revolutions per Minute	Gallons Pumped per Minute.	Direct or Belted Connection.	Greatest Total Lift in Feet.	Cost Repairs per Season.	Difficulties in Operating and Criticisms.	Would You Replace With Same?	If Not, Why?	And With What?
I RIO GRANDE VALLEY AND NEW MEXICO. (a) Rio Grande Valley														
Barker, F C.	Las Cruces, N. M.	"Ordinary triple action."	a	a	1	60	78	Belted	18	5 00	"Not enough water" h	Yes		
Bueher, Hermau.	Albuquerque, N. M.	Marsh Pump Co., Battle Creek, Mich., D Tank Pump (c)	250.	2.50	4	65	166		8	1 75	None	Yes		
Cadwallier, E. F.,	El Paso, Tex.	El Paso Foundry Co., 10" cyl., 14" stroke.	33.	8.	3 1-2	33	275		22	15 00	Valves get loose, plunger dries out and is cut by sand.			
Hadlock, E. J.,	El Paso, Tex.	Otto Dbl. action, 9¼" cyl., 12" stroke	1100.d	10.d	20	64	450	Direct	10	2 00d	None	Yes		
Howland, A. M.,	Doña Ana, N. M.	Holyoke (Mass.) Steam Piston Duplex.			90		1000							
Kezer, H A,	El Paso, Tex.	Gould's Centrifugal.	60.		5	750	452	Belted	12	1 00	None; high speed not economical.	No		Endless chain
Mann Bros.,	Albuquerque, N. M.	Seaman & Shuskey Elevator bucket pump.	89.	17.	1 1-2		166	Belted	18	None	None	Larger		
Porcher, J. Stoney.	El Paso, Tex.	Davis Johnson & Co., Chicago, Ill., Johnson Rotary No. 5.	175.	5.50	5	120	475	Belted		None	None	Yes		
Porcher, Julius T.,	Socorro, Tex.	Davis Johnson & Co., Chicago, Ill., Johnson Rotary No. 6.	250.	1.25	10	108	750	Belted			None except in priming	Yes		
Rouault, T.,	Las Cruces, N. M.	Centrifugal.	750.e	25.	8		1200 f	Belted	12		None	Yes		
Smith, J. J.	Ysleta, Tex.	Otto combined engine and pump.	*				400	Direct			None	Yes		
Tibbetts, J.,	El Paso, Tex.	El Paso Foundry Co., Pluuger.			5	35	350	Belted	20	2 00	None; except filling of pump with sand & gravel	No	Requires too much power	Centrifugal
(b) Other Points in New Mexico.														
Andrews, Dr. E.,	Santa Fé, N. M.	Aermotor Irrigating Pump, 8 inch, Aermotor Co. Chicago, Ill.	34.g	12.00h	1-2	30i	80		4	None	None	Yes		
Botulph, Brother.	Santa Fé, N. M.	Delameter-Ericson No. 2 combined hot-air engine and pump.	300.c				18		12	None	None	Yes		
Hogie, A. P.,	Santa Fé, N. M.	Aermotor Co., Chicago, Ill.	16.j		2 1-2	30	60	Belted	44	None	None	Yes		
Kerr, T. R.,	Cambray, N. M.	Woodmanse Mfg. Co, Freeport, Ill., suction	30.j	2.	1		2	Direct	20	2 00	Replacing Leathers	Yes		
Lee, Jesse D.,	Roswell, N. M.	Brass 4" diam., 8" stroke.	12.50j			35	14							
Smith, P. R.,	Deming, N. M.	Snow Mfg. Co, Buffalo, N Y.		400.	50		200	Direct	70	Nominal	None	Yes		
II CALIFORNIA.														
Ellerby, F. W.,	Pasadena, Cal.	Krough Pump Co., San Francisco, Cal., Centrifugal No. 2.	60.	2.	4	1200	99	Belted	40	Slight	None except in packing from improper alignment	Yes		
Medearis, James S.,	Lamanda, Cal.	Byron-Jackson Co., San Francisco, Cal., Centrifugal No. 3.	72.	80.1	5	1250	225	Belted	47	7 50	Must be properly packed or will lose suction.	Same make	Too high speed	
Merwin, Duncan S.,	Pasadena, Cal.	Ames-Fulton Co, Galt., Cal, variable motion, double acting.	500.k		5		150	Belted	60	None	None	Yes		
III COLORADO														
Behrens, John H.,	Evans, Colo.	Fairbanks, Morse & Co., Denver, Colo, centrifugal	90.	2.	5		m	Belted	6	None	None	Yes		
Blandin, O. J.,	Eaton, Colo	Centrifugal No. 5	110.	Nominal	12	225	496	Belted	31	1 00	None	Yes		
Brownell, Archie W.,	Greeley, Colo.	Boggs & Clark Centrifugal		6.	12			Belted		10 00	None if pump kept solid	Yes		
awson, Garrett.	Longmont, Colo.	Fairbanks Morse & Co., Denver, Colo., Vert. Centrifugal No. 6.	109.	130.n	22			Belted	22	None	None	Yes		
McKenney, Charles,	La Salle, Colo	Gould's Horizontal Centrifugal No. 4.	90.	3.	6	650	550	Belted	6		None	Yes		
Osterhont, Geo. E.	New Windsor, Colo.	Boggs & Clark, Syracuse, N. Y., Centrifugal No. 6.	125.	3.50	10	600	o	Belted	15	Slight	Requires cleaning of foot valve.	Yes		
Prendergast, B. J,	Brighton, Colo.	Irvin Van Wie, Syracuse, N. Y., Vert. Centrifugal No 3 1-2		7.	5		350	Belted			None	Yes		
IV MISCELLANEOUS.														
Ellis James.	Welsh, La.	Connorsville Blower Co., Connorsville, Ind, Cycloidal.	500.p	15.	12	150	1000	Direct	30	None	None	Yes		
Green and Shoemaker,	Crowley, La.	Connorsville Blower Co., Connorsville, Ind., Rotary.	1700	65.	30	140	4000q	Belted	16	None	None	Yes		
Perry A. S.	Yukon, Okla.	Gould Pump Co., Centrifugal No 4	100.r	7.	11	1000	1000	Belted	22	None	None	Yes		

a. Cost of pump, engine and earth reservoir, $703.

b. "Not enough flow of water, and this difficulty will always make pumping for irrigation impracticable in this valley except for very expensive crops."

c. Steam pump, no engine is required; uses three.

d. Includes cost of pump and engine.

e. Includes cost of engine and boiler.

f. From open body of water.

g. Including 20 ft. pipe and rod. For 6 ins. pump, 18 ins. long, including same, $20 00.

h. Including cost of placing windmill.

i. In 15 mile wind, being attached to windmill.

j. Cost of cylinder only.

k. Including cost of placing.

l. Including cost of shaft 6'x6', 25' deep, curbed with 2"x12" redwood.

m. "100 inches per second."

n. Including cost of placing engine.

o. "60 to 100 inches."

p. Including cost of boiler.

q. Capacity.

r. Including cost of belt.

TABLE NO. 11.

Data Concerning Engines

Name	Address	Manufacturer and kind of engine	Cost	Cost of placing	Actual horse power	Working speed	Kind igniter in use	Years in use	Cost of repairs per season	Cost of oil per gallon or wood per cord	Cost fuel for 10 hours	Operated with common or skilled labor	Difficulties in operating and criticisms	Would you replace with same?	If not, with what ·
I RIO GRANDE VALLEY AND NEW MEXICO (a) Rio Grande Valley															
Barker F. C.	Las Cruces, N. M.	F. M. Watkins Co. Cinecinnatti, O. (a)	$ 703 (c)	(c)	2	60	Batt'y.	3	$25.00	$ .30	$1.20	Com.	All troub'e that could occur. Engine too delicate	No	Otto.
Cadwallader, E. F.	El Paso, Tex.	Skillin & Richards Mfg. Co., Chicago, Ills "Burrell." (a)	175	$ 5.00	3 1-2	280	Tube		1.50	.16	.85	Com.	Slight	Lárger	
Hadlock, F. J	El Paso, Tex.	Otto combined engine and pump (a)	1100	10.00	6	210	Dynamo	2 1-2	2.00	.15	.90	"Wife"	None	Yes	
Kezer H. A.	El Paso, Tex.	Charter Engine Co, Sterling, Ills. (a)	600		10	150	Tube	1 1-2	2.50	.16	1.12	Com.	None	Yes	
Lo man, H. C.	San Marcial, N. M.	Cooper Engine Co. Semiportable, Mt. Vernon, O. (b)			20	60		5	None	2.50	2.50	Skilled	Prefers boiler and engine separate	No	
Mann Bros.	Albuquerque, N. M.	Fairbanks, Morse Co, Beloit, Wis. (a)	300	9.50	4	300	Battery & tube	1 1-3	12.00	.25	.80	Com.	None	Yes	
Porcher, J. Stoney	El Paso, Tex.	Columbus Mchn. Co., Columbus, O. (a)	275	3.00	5	210	Batt'y.	1 1-2	None	.16	1.12	Self	Trouble with igniter and starting but very economical	Yes	
Porcher, Julius T.	Socorro, Tex.	Ohio Motor Co, Sandusky, O. (a.)	475	6.00	10	210	Dynamo	1-6	None	.16	1.92	Self	None	Yes	
Rouault, T.	Las Cruces, N. M.	T. M. Nagle, Erie, Pa., Portable (b)	750 (e)		10	125		4	2.00			Com.	None	Satisfied	
Smith, J. J.	Ysleta, Tex.	Otto combined engine and pump (a)	1100 (d)	5.00	6	150	Batt'y.	1 1-3	2.50	.15	1.00	Self (f)	None	Larger	
Tibbetts, J.	El Paso, Tex.	Chart er Engine Co., Sterling, Ills. (a)	526 (g)		8	200	Batt'y.	1	None	.16	1.28	Skilled (f)	Stops sometimes from unknown cause	Larger	
(b) Other Points in New Mexico															
Botulph, Brother	Santa Fé, N. M.	Delamater-Ericson No. 2, combined hot air engine and pump	$300 (d)					17	Slight			Com.		Yes	
Harroun, Dr. W. S.	Santa Fé, N. M.	Fairbanks, Morse & Co. (a)													
Hogle, A. P.	Santa Fé, N. M.	Webster Mfg. Co, Chicago, Ills. (a)	151	10.	2 1-2	320	Tube	1	None	.31	.78	Self	None	Yes	
II CALIFORNIA															
Eerby, F. W.	Pasadena, Cal.	Lambert Engine Co., Anderson, Ind. (a)	$295	4.00	4	274	Batt'y.	3	$ 5.50	.9 (h)	.41	Com.	No difficulties; uses too much oil	No	White and Middleton
Medearis, Jas. S	Lamanda, Cal.	White & Middleton, Baltimore, Md. (a)	470	12.00	7	260	Batt'y.	2	6.00	10.1-2 (i)	.55	Com.	With distillate slight trouble; with gasoline none	Yes	
Merwin Duncan S.	Pasadena, Cal.	Lambert Engine Co., Anderson, Ind. (a)	500 (j)		8		Batt'y.	2	1.00	.12 (i)	1.00	Com.	None	Yes	
III COLORADO															
Brownell, Archie W.	Greeley, Colo.	Fairbanks, Morse & Co. (a)	$ 683	30.	12		Batt'y.	1-2	None	.23	$2.50	Com.	None	Yes	
Blandin, O. J.	Eaton, Colo	Fairbanks, Morse & Co. (a)	700	35.	12	225		1-6	None	.21	2.18	Skilled	None	Yes	
Behrens, John H.	Evans, Colo.	Fairbanks, Morse & Co. (a)	350	15.	5		Batt'y.	1-6	None	.20	.90	Com.	Stops occasionally		
Clawson Garrett	Longmont, Colo.	Fairbanks, Morse & Co. (a)	1000	115.	22		Batt'y.	1	None	.20	3.33	Com.	None	Yes	
McKenney, Charles	La Salle, Colo.	Fairbanks, Morse & Co. (a)	551	1.50	8	250	Batt'y.	1-3	None	.20	1.00	Com.	None	Yes	
Osterhont, Geo. E.	New Windsor, Colo.	Chandler & Taylor (b)	140	12.	15	140		4 1-2	None		1.50	Skilled	None	Yes	
Prendergast, B. J.	Brighton, Colo.	Fairbanks, Morse & Co. (a)	325	7.	5	325		1-6		.24	1.20	Com.	Gummed by crude oil when generator not in use	Yes	
IV MISCELLANEOUS															
Elis, James	Welsh, La.	Troy, Pa, Upright (b)	$1250 (k)	15. (l)	12 1-2	190		1	None	.01 1-2 (m)	2.93 (n)		None	Yes	
Green & Shoemaker	Crowley, La.	Erie Engine Works "Skinner" (b)	1700 (k)	6.	40	175		11	.75	.01 (n)		Skilled	None	Yes	
Perry, A. S.	Yukon, Okla.	Fairbanks, Morse & Co. (a)	598	33.	12	225	Batt'y.	1	3.25	.15 3 4	1.90	Com.	None	Yes	

a. Gasoline engine
b. Steam engine
c. Includes cost of engine, pump and earth reservoir
d. Includes cost of engine and pump
e. Includes cost of boiler and pump

f. "Could be run as well by common labor
g. Includes cost of engine, pump and pipe for one well
h. Distillate in 100 gallons quantities
i. Distillate
j. Includes cost of placing

k. Includes cost of engine, boiler, pump, fixtures, etc.
l Includes cost of foundation for pump
m. Crude oil, 42 gallons for 65 cents; coal $4.20 per ton
n. Crude oil; coal $5.60

Pumping Plants.

Crop Grown.	Any Harmful Effects of water on Crops?	Has n Ir- om lant.	Does it Pay to Pump for Irrigation?	Profit per Acre.
egetables	No		(b.)	(c.)
egetables	Yes (d.)		No (e.)	
uit and Veg.	No			(f.)
eg. & alfalfa	No		Yes	$111.11
eg., flowers and trees	No		Yes	$50.00
egetables	No		No (1.)	
egetables	No		No	
uit, veg. and alfalfa	No		Yes	$20.00 to $75.00
egetables	No		Yes	
uit and vegetables	No		Yes	$50.00 to $200.00
uit and vegetables	No		Yes	$40.00
ruit, veg. and alfalfa	No		Yes	$100.00

TABLE NO. 12.

Data Concerning Land Irrigated by Pumping Plants.

Name	Address.	Acres Irrigated	Other Sources of Water.	What Proportion Whole Season Pump for Irrigation.	Method of Applying Water.	Number of Irrigations	Total Number of Inches Applied.	Cost of Applying Water Per Acre.	Average Time Between Irrigations.	Crop Grown.	Any Harmful Effects of water on Crops?	Kind of Soil.	Kind of Sub-Soil.	Fertilizers Used.	Reservoirs or Tanks.	Capacity of Same.	How Long Has Land Been Irrigated From Pumping Plant.	Does it Pay to Pump for Irrigation?	Profit per Acre
I. RIO GRANDE VALLEY AND NEW MEXICO. (a) Rio Grande Valley.																			
Barker F. C.	Las Cruces, N. M.	6	River	One-half	Furrow (mostly)	5	15	$30.00 a.	15 days	Vegetables	No	Lt. sandy loam	Clay	Manure	Earth	60,000	3 years	(b.)	(c.)
Rueher, Herman.	Albuquerque, N. M.	20	River	Av. 3 weeks	Flooding and Furrow			.50	10 days	Vegetables	Yes (d.)	Sandy loam	Clay and gravel	Manure	Earth —cost $250	1 acre 4 ft. deep		No (e.)	
Cadwallader, E. F.	El Paso, Tex.	20-25	River		Usual				12 days	Fruit and Veg.	No	Sandy loam		None	None		2 years		(f.)
Hadlock, E. J.	El Paso, Tex.	40	River (g.)	8 months	Flooding and Furrow (h.)	(i.)			15 days	Veg. & alfalfa	No	Sandy adobe	Sandy adobe	None	None		2¼ years	Yes	$11.11
Kezer, H. A.	El Paso, Tex.	40	None	All	Flooding and Furrow				8 days (j.)	Veg., flowers and trees	No	Hvy. adobe and light sandy loam	Sand	Manure (k.)	None		1½ years	Yes	$50.00
Lehman, H. C.,	San Marcial N. M.	5	River	2 months	Flooding and Furrow			.50	15 days	Vegetables	No	Sandy loam	Some adobe	None			1 year	No (l.)	
Mann Brothers (m.)	Albuquerque, N. M.	36	River	2 months	Flooding			$32.00 (m.)	10 days	Vegetables	No	Sandy loam	Sand	Manure	Earth —cost $150	1½ acre 2½ ft. deep	1½ years	No	
Porcher, J. Stouey,	El Paso, Tex.	25	River	¾	Flooding		3 ins. each time		7-20 days	Fruit, veg. and alfalfa	No	Hvy. sandy loam	Sand	Manure	None		1½ years	Yes	$20.00 to $75.00
Rouault, Theodore.	Las Cruces, N. M.	150	River (n.)	1 month	Furrow	2		.25	20 days	Vegetables	No	Spotted		Manure			4 years	Yes	
Smith, J. J.	Ysleta, Tex.	35	River	All	Flooding and Furrow			.25	2-8 weeks	Fruit and vegetables	No	Sandy loam	Sandy loam	Manure	None		1½ years	Yes	$50.00 to $200.00
Tibbets, J.	El Paso, Tex.	35	Slight	All	Flooding and Furrow			.20	1-4 weeks	Fruit and vegetables	No	Sandy loam	Sand	None	None		1 year	Yes	$40.00
(b). Other Points in New Mexico.																			
Andrews, Dr. F.,	Santa Fe, N. M.	6	Ditch	3 months	Flooding				2-4 weeks	Fruit, veg. and alfalfa	No	Sandy grave	Sandy gravel	Manure	25'x75'x4' — cost $50.00		10 years	Yes	$100.00
Chisum, William,	Roswell, N. M.	2½	River	⅓	Furrow				2 weeks		No	Sandy loam	Clay	Manure	40'x46'x3' —cost $15.00		5 years	Yes	
Hogle A. P.,	Santa Fé, N. M.	8	Ditch	2 months					15 days	Fruits								Yes	
Lee, Jesse.	Roswell, N. M.	2	None	¾	Furrow				2 weeks	Fruits and vegetables	No	Adobe	Gypsum and gravel		Earth —cost $15.00	17,000 gallons	2 years		
Smith, P. R.,	Deming, N. M.	25	None	3 months	Flooding and Furrow			$5.00 to $10.00	2 weeks	Fruits, veg. and alfalfa	No	Sandy loam	Cement clay	None	Earth —cost $4,000	30,000,000 gallons	8 years	Yes	$.75 to $200.00
II. CALIFORNIA.																			
Ellerby, Fred W.,	Pasadena, Cal.	8	None	½	Furrow		11	$12.50	Varies	Strawberries	No	Sandy loam	Loam, sandy gravel & clay	Manure	None		3 years	Yes	
Merwin, Duncan S.,	Pasadena, Cal.	10	None	All	Furrow	3 to 4			6 weeks	Citrus fruits		Pt. heavy Pt. Sandy		Manure	Tank, —cost $300.00	6000 gallons			
III. COLORADO.																			
Behrens, John H.,	Evans, Colo.	80	Ditch	3 months	Flooding and Furrow	3 to 6			3 weeks	Grain and vegetables	No	Loam	Sand	None	None		1 year	(o.)	
Blandin, O. J.,	Eaton, Colo.	63	None	3 months	Flooding and Furrow			$3.47		Hay, grain, vegetables	No	Clay loam	Clay gravel	Very little	None		1 year	Yes	
Clawson, Garrett,	Longmont, Colo.	74	Ditch	3 weeks				$1.10		Grain, etc.	No	Clay and sand	Clay	None			1 year	Yes	
Osternont, Geo. E.,	New Windsor, Colo.	40	Ditch	All	Flooding and Furrow			$5.00		Wheat and potatoes	No	Clay and sand	Clay	Manure and alfalfa	None		10 years	"Depends"	
Reinhardt, C. W.	Brighton Colo.	17	Ditch	3½ months						Vegetables				Some	None				
IV. MISCELLANEOUS.																			
Ellis, James,	Welsh, La.	150	None	70 days	Flooding	Continuous	4 to 7	$2.00	Continuous	Rice	No	Loam	Clay	None	None			Yes	
Green & Shoemaker	Crowley, La.	480	None	3 months	Flooding	Continuous	½ to 6	$3.75	Continuous	Rice	Yes (p.)	Clay loam	Clay	Commercial	None		11 years		$10.00 to $20.00 (q)
Perry, A. S.,	Yukon, Okla.	10	None	5 months	Furrow			50 c. per inch	10 days	Nursery stock, fruits & veg.	Yes (r.)	Sandy loam	Sand	Manure	None		1 year	Yes	Depends on crop

a. "But would be many times more if not assisted by river water."
b. "Not in a general way."
c. "Ask another."
d. "Plants more subject to diseases."
e. "It pays to supplement river rather than lose crop."
f. "You guess."
g. "Will abandon this source on account of Johnson grass."
h. "Vegetables by furrow; alfalfa by flooding.
i. "Alfalfa, two to each crop; vegetables 3 or 4 to each crop.
j. In May, June, July. Floods heavily before putting in crops in order to remove salts in soil.
k. "And will use bonemeal."
l. "Because there is no market here."
m For a season of nine months, estimated.
n. Pumps from reservoir filled by ditch.
o. Raises beets (20 tons per acre); grain (30 bu. per acre); and potatoes (150 bu. per acre); thinks it will not pay if water is lifted over 7 or 8 ft.; has had but 1 year's experience.
p. From salt water from Gulf of Mexico entering well when fresh water is exhausted.
q Has realized $100 per acre, and other years total loss; "the careful farmer may safely count on from $10 to $20 an acre while the present tariff remains."
r. "When applied in too great quantity."

TABLE NO. 13.

Railroad Pumping Plants in New Mexico Along the Line of the Santa Fe Railway

Station	Wells			Water				Power	Pumps	Fuel	Tanks	Capacity of plant	Cost of plant	Date plant erected	Remarks
	No.	Diameter	Depth in feet	Curbing	Cost	Quality	Quantity								
Alamillo	1	8 ft	22	Stone		Good	Abundant	Windmill and standard 4 flue boiler	Knowles No 6	Slack coal	1 20 ft	5000 gallons per hour	$3125	1881	
Albuquerque	6	10 ins	70			Good	Sufficient	Steam	Snow low pressure, 20 h p (a)		1-43 ft steel	1000000 gallons in 24 hours			Wells have com'on points 8 ft long (b)
Bernalillo	1	7 ft	12	Stone	$ 500	Alkali	Limited	Standard boiler and windmill	Knowles No 5	Slack coal	1-26 ft				
Colmor	1	13 ft	14	Stone	$1500	Good	Limited	Windmill			1-20 ft				
Crawford	1	8 ft octagon	41	Wood		Good	Medium	Windmill 22 ft wheel 50 ft tower	Armstrong		1-20 ft			1882	
Dorsey	1	22 ft square	20	Wood	$ 775	Fair	Medium	Standard boiler and windmill	Knowles No 6 & windmill pump	Slack coal	1-24 ft				
Earlham	1	12 ft square	17	Wood		Good	Sufficient	Standard 4 flue boiler; windmill 20 ft wheel 50 ft tower	Knowles No 6 and Armstrong windmill pump	Slack coal	1-24 ft		$2200 $2500	1889	
El Paso, Texas	1	9 ft square	17	Wood		Fair	Scarce	26 2 3 in flue boiler horizontal	A A Knowles	Slack coal	1-24 ft		$2500		
Hatch	1	8 ft	17	Stone				Standard 4 flue boiler	Knowles No 6		1-24 ft	5000 gallons per hour			
Lamy	1	18 ft	17	Stone	$1400	Good	Unlimited	Standard boiler	Knowles No 6	Slack coal	1-24 ft				Well is 4 miles distant in mountains
Las Cruces	1	18 ft	21	Stone		Medium	Medium	Standard 4 flue boiler and aermotor windmill 60 ft tower	Knowles No 6	Slack coal			$3040 excluding windmill	1881	
Los Lunas	1	8 ft	15			Fair	Sufficient	Standard 4 flue boiler, Armstrong windmill 18 ft wheel 50 ft tower	Knowles No 6	Slack coal	1-20 ft	5000 gallons per hour	$3155	1881	
Otero	1	17 ft	35	Stone	$2000	Good	Ample	Standard boiler	Knowles No 6	Slack coal	1-20 ft				
Ribera	1	21 ft	12	Stone	$1800	Good	Limited	Standard boiler	Knowles No 7	Slack coal	1-24 ft				
Rincon	1	11 ft 6 in square	17	Wood		Good	Sufficient	2 standard boilers 4 flue 6 ins	Knowles, 1 B B, 1 No 6	Slack coal	1-20 ft 1-24 ft	7500 gallons in 24 hours	$7000		
Rowe	1	18 ft	25	Stone	$1900	First class	Unlimited	Ret. flue boiler; 15 h p	2 Knowles D	Wood	2-20 ft				
Sabinal	1	8 ft	18	Stone		Poor	Sufficient	Standard 4 flue boiler, Armstrong windmill 18 ft wheel, 50 ft tower	Knowles No 6	Slack coal	1-20 ft	5000 gallons per hour	$3260	1881	
San Antonio	1	11 ft	22	Stone		Good	Sufficient	Standard 4 flue boiler; windmill 20 ft wheel, 50 ft tower	Knowles No 6	Slack coal	1 24 ft	7000 gallons per hour	$3500		
Seldon	1	8 ft	15	Stone		Good	Good	Standard 4 flue boiler	Knowles No 6	Slack coal	1 24 ft	50000 gallons in 24 hours	$2600		
Shoemaker	1	18 ft	30	Stone	$1800	Best	Ample	Standard boiler	Knowles No 7	Slack coal	1-24 ft	80000 gallons in 24 hours			
Wagon Mound	1	14 ft by 45 ft	15	Wood	$ 480	Very good	Abundant	Standard boiler	Knowles No 6	Slack coal	1-24 ft	80000 gallons in 24 hours			
Whitney	1	17 ft 6 ins	65	Stone		Good	Abundant		1 Deming deep well; 1 Knowles A A	Mixed coal		150000 gallons in 24 hours	$6655	1881	

a. Will change to high pressure
b. Believes if not constantly pumped, points would clog

ble distribution is entirely eliminated. 4th, there are no long ditches to maintain at great cost, and 5th, the initial cost is within the means of every farmer.

The writers, however, believe that a combination under favorable circumstances, of these two systems will prove not only satisfactory but at the same time the most economic method of producing large quantities of water for irrigation during droughty periods. This combination consists in the maintenance of individual pumping plants upon each farm, thus securing all the desirable features of such plants as heretofore enumerated, and at the same time eliminating the objectionable points proposed against a single large pumping plant at the head of a ditch; in conjunction with these a centrally located electrical power plant, through which the farmer would receive the benefits of efficiency of control and economy of production which such a power plant should give.

Another suggested plan is to maintain along the line of a ditch, at suitable distances apart, pumping plants of sufficient capacity to supply the land to be watered from each, such plants to be operated by a central electrical power plant; and there would seem to be nothing to prevent a successful working of this plan.

COST OF A PUMPING PLANT

Under a system of cooperation, a pumping plant should not cost each farmer more than $350.00 to $400.00. This figure includes the two items of well and pump. If, however, an individual pumping plant is to be installed, to the items of say $200.00 for the well and $200.00 for one of the pumps giving the best results in the test, the cost of an engine must be added. This will be found the most expensive item. Engines, both steam and oil combustion, vary considerably in price, and, therefore, it is impossible to give definite figures on the cost. An engine large enough to furnish power for pumping 1000 gallons per minute would probably cost from $900.00 to $1,500.00 depending upon the make. It is probably safe to say that for supplying water for large areas, an individual pumping plant would cost not far from $10.00 for each acre of land irrigated.

CARE OF BOILERS, ENGINES AND PUMPS

By J. S. MacGregor, Assistant in the Department of Mechanical Engineering.

The following general statements on the care and operation of boilers, engines and pumps are intended for laymen, and if carefully adhered to will add to the life, safety and economy of pumping plants.

The Boiler

Before firing see that there is a moderate supply of water in the boiler. The fire should then be raised gradually so that the metal in the shell may expand evenly. Next regulate the feed pump, or injector, to supply water as steam is used. Keep the wood or coal spread evenly over the grate, and do not allow the great bars to become bare, as cold air will rush in and cool the heating surface. The thickness of the fire will depend on the draft; if the draft is strong the fire should be heavier than if it is weak. When burning wood maintain a bed of live coals about three inches deep with plenty of wood on top to maintain this thickness. In order to clean the fire push the upper part of the fire to the back of the grate, remove ashes and cinders, then pull the fire forward and draw the ashes and cinders of the back over the fire into the ash pit, distribute the fire evenly over grate and add new fuel. If burning soft coal break the fire up occasionally with a bar as it has a tendency to crust on top. Do not allow the ash pit to become full of ashes as there is danger of burning out the grate bars in such case.

When working with fire or firing do so as quickly as possible for cold air rushing in not only cools the boiler, but also causes uneven contraction in it, and uneven contraction and expansion of the shell and tubes of a steam boiler do it great injury. Leakage and cases of rupture are often caused by forced heating and cooling. Be moderate in everything that tends to change the temperature of the boiler. The safety or pop valve should be raised once or twice a day when under pressure doing so very gently to make sure it is in working order.

Sediment collects in all boilers, due to the precipitation of solid matter in feed water used. This sediment forms a scale, and the presence of a scale results in fuel loss. It has been estimated that one-sixteenth inch causes a loss of 13 per cent. of fuel, one-fourth inch 38 per cent., and one-half inch 60 per cent. Further, the circulation of water in the boiler causes loose particles of this scale to be deposited in some one place, which is generally over the fire box. This place becomes overheated and results in "bagging." In order to avoid the accumulation of sediments with the resulting evils, open the manhole and clean the boiler out occassionally; or boiler compounds may be used which aid in decomposing the scale.

The Engine

The following directions pertain to the ordinary types of stationary steam engines. Before starting the engine, oil up all around, and see that the cylinder lubricator is in working order. Then open all drain cocks, open throttle valve slightly, and allow the steam to warm the walls of the steam chest and cylinder. Now start the engine slowly and allow it to run a few minutes before closing drain cocks, for if drain cocks are closed too soon water will collect in the cylinder and either split it or burst out the head. During the run feel the bearings occassionally avoid all lost motion by keeping parts well tightened up.

On closing down first open drain cocks, then close throttle slowly allowing the engine to slow down gradually. Never close or open the throttle-valve quickly. If any unusual noises occur during the run close down immediately and investigate. Clean off the engine thoroughly after each run. It pays to use a good quality of cylinder oil. Give the cylinder oil in quanties of about one drop a minute.

The method of starting and stopping gas and oil engines vary so much with different makes that we have not enumerated them here. Suffice it to say that the same caution should be taken about oiling up, and keeping all parts tightened as with steam engines.

Pumps

In order to start a centrifugal, or rotary pump, it is first necessary to raise the water into it. This can be done by use of the ejector, when in connection with a steam plant. To do this, close the mouth of the exhaust water pipe by some convenient means, a good way being to place a piece of soft leather, stretched on a board, over it. Now turn steam through the ejector; this will exhaust the air and raise the water into the pump. When this is done start the engine, gradually coming to speed. If the pump is run by a gas or oil engine, an ordinary hand pump may be used to raise the water. During the run keep the bearings of the pump and counter shaft, if any, well oiled. Feel each occasionally. Keep the belts in good condition, and avoid slippage by the use of belt dressing. A pump fails because it leaks; there can be no other reason; find the leak and repair it. Leaky valves can be repaired by grinding valve seats. Always drain the pump in cold weather, for water remaining in it will probably freeze and either loosen joints or burst the pump. Lastly always keep material for gaskets and packing on hand.

ACKNOWLEDGMENTS

Available literature upon the subject of pumping for irrigation has been freely consulted by the writers in planning the tests reported in this bulletin and in its preparation. Grateful acknowledgment is hereby given for the general interest and encouragement received from the citizens of the Rio Grande Valley of New Mexico, and from those in various parts of the country, who have aided the work of securing data by filling in the blanks sent out. The writers wish to acknowledge their indebtedness to the Mechanical Engineering Department of the College for ready assistance given in

the use of tools, operation of machinery and for various supplies provided during the progress of the work; to Prof. A. B. Sage, of that department, who accompanied one of the writers on a tour of inspection of the pumping plants of New Mexico; to Mr. J. S. MacGregor of the same department, and to Prof. J. D. Tinsley, the soil physicist, for valuable and timely assistance throughout the progress of the work; and to the Chemical Department of the College for analysis of water furnished; to the F. H. Bascom Co., of Las Cruces, New Mexico, for the loan of sundry equipment; and to the Atchison, Topeka & Santa Fe Railroad Company for transportation facilities and courtesies extended. Acknowledgment should also here be made to the Aermoter Company of Chicago for providing the institution with a complete Aermoter wind-mill tower and pump for irrigating purposes, the results of tests with which will be published later; and to Irvin Van Wie of Syracuse, New York, for the gift to the institution of the five-inch centrifugal pump used in connection with the pumping tests reported in this bulletin.

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BULLETIN NO. 46

MAY 1903

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

SOIL MOISTURE INVESTIGATIONS

FOR THE SEASONS OF 1901 AND 1902

BY

J. J. VERNON and J. D. TINSLEY

SANTA FE, N. M.
New Mexican Printing Company
1903.

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The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others as far as the editions printed will allow.

*Resigned, April 1, 1903.

SUMMARY

1. It is practically impossible with ordinary implements to produce a dust mulch on the clay loam and clay soils of the Mesilla Valley.

2. While the "Mexican Method" of three irrigations will produce a fair crop of corn, it is probable that in ordinary seasons from one to three additional irrigations may be given with advantage.

3. In general, the moisture content of the soil and yield of corn increase with the number of irrigations; but on the individual plats there is little if any connection between moisture content and yield.

4. The custom in this valley of partially substituting irrigation for cultivation is not without some foundation. The moisture content of the soil and the yield of corn are not materially increased by frequent surface cultivations on these soils.

5. Sub-soiling in these tests has not proved to be of marked advantage.

6. On this soil, clay loam, corn wilts when the amouut of moisture falls much below 20 per cent.

7. The benefit derived from winter irrigation will depend mainly on the texture of both surface and sub-soil. In these tests its benefit was confined mainly to insuring good germination.

8. In the clay loam soils of the Mesilla Valley, lateral percolation is very slight.

9. Owing to variations in the soil, and probably undetermined influences, definite conclusions on these subjects cannot be drawn without extended research.

INTRODUCTION

The experiments on soil moisture reported in bulletins Nos. 31 and 38 of this station were repeated during 1901 and 1902.

These experiments were conducted in order to obtain information on the following questions:

1. How do the yields of corn irrigated in the Mexican way compare with those obtained by using more frequent and less frequent irrigations?
2. What is the relation between the amount of moisture in the soil, the number of irrigations, and the yield of corn?
3. What is the effect of different numbers of cultivations on both the moisture content of the soil and the yield of corn?
4. Does sub-soiling have any marked effect on either the moisture content of the soil or the yield of corn?
5. What is the amount of moisture in the soil when corn shows decided drouth effects?
6. Does irrigation applied in winter have any marked effect on the moisture in the soil during the spring and summer?
7. Is there any great amount of lateral percolation in the soil?

The work, as in former years, was carried on jointly between the departments of agriculture and soils. The department of agriculture had charge of the planting, cultivation, irrigation, and observations on growth and yield; the department of soils took the samples, made the moisture determinations and studied the soil.

Professor Fabian Garcia made the field observations and superintended the irrigation and cultivation for the department of agriculture in 1901 and Mr. J. W. Bouts in 1902.

Mr. A. M. Sanchez took the most of the samples and made the moisture determinations for the department of soils in 1901 and Mr. R. H. Hart in 1902.

PLAN OF EXPERIMENTS

Location:—The land used in the soil moisture investigations during 1899 and 1900, the results of which are reported in bulletins Nos. 31 and 38, proved to be so very uneven in its character that it was decided to use another piece of land for 1901 and succeeding years.

The piece of land chosen for the work lies on the east side of the farm only about 200 yards from the eastern limit of irrigation, or near the extreme eastern side of the river valley. This eastern boundry of the land now under irrigation, or river valley proper, is formed by a terrace from which the land slopes upward toward the foot hills.

This piece of about two acres was divided into twenty plats for 1901, and in 1902 an additional row of four plats was added on the south side making the number twenty-four for 1902. In addition to these a space about fourteen feet wide was left between the north row of plats and the next row on the south. Another similar space was left between this second row, from the north, and the third row.

The general arrangement of the plats will be readily understood from the accompanying diagram. The second row was to receive the maximum number of irrigations and the spaces were left to prevent lateral percolation to the first and third rows.

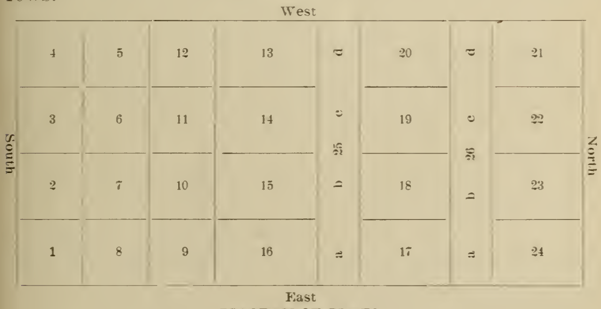

DIAGRAM OF PLATS

Each plat was surrounded by a border high enough to hold the irrigating water applied. The plats were planted to corn as in the previous years.

Irrigation for 1901:—Plats 7*, 8, 25 and 26 were to be irrigated when the corn was a few inches high, and no more during the season in order to study the drought condition.

Plats 5 and 6 were to be watered as the corn seemed to need it.

Plats 9, 10, 11 and 12 were to receive the minimum number of irrigations, the first when the corn was a few inches high, and the second at tasseling.

Plats 13, 14, 15, 16, 21, 22, 23 and 24 were to be irrigated in the ordinary Mexican way, the first irrigation to be given at the time of planting, the second before tasseling, and the third when the grain was forming.

Plats 17, 18, 19 and 20 were to be irrigated every ten to fourteen days, which was to be the maximum number of irrigations.

Cultivation for 1901:—Plats 12, 13, 20 and 21 were to be cultivated once a week; 11, 14, 19 and 22 once in two weeks; 10, 15, 18 and 23 once in four weeks; 9, 16, 17 and 24 were to be cultivated at the discretion of the agriculturist; and 5, 6, 7 and 8 were used as a term row and cultivated irregularly.

Irrigation for 1902:—It was decided this season to test the effect of winter irrigation upon the spring and summer moisture content of the soil. The winter irrigation was applied to all of the plats, except 5 to 8, on March 12.

Plats 1 and 2, and 25 and 26 were to be used for the study of drought.

Plats 3 and 4 were to be irrigated whenever they seemed to need it, about five irrigations.

Plats 5, 6, 7 and 8 had no winter-irrigation and were to receive the ordinary Mexican treatment, first irrigation at planting, second before tasseling and third when the grain was beginning to form.

*The plats are numbered according to their arrangement in 1902.

Plats 9 to 12 were to receive two irrigations, the first at planting and the second at tasseling.

Plats 13 to 16, and 21 to 24 were to receive three irrigations according to the Mexican method as outlined above. Plats 21 to 24 had been sub-soiled in 1901 and were again sub-soiled in 1902.

Plats 17 to 20 were to receive the most frequent irrigations, which were to be every 10 to 14 days.

MOISTURE DETERMINATIONS

In the spring of 1901, forty pairs of electrodes were installed in the twenty plats with the expectation of using the electrical method of moisture determination. There were so many failures in the electrodes and temperature cells that by June 29th, practically no continuous records had been obtained so it was then abandoned for the method of sampling and weighing.

There were several sources of trouble in working with the electrical method.

First. Leakage of temperature cells. The adjustable temperature cells which were used leaked so badly that they had to be abandoned. Their range of adjustment was not great enough to adapt them to the great variation in water content of these soils. When the soils became very dry, the cells had to be removed and replaced by others of higher resistance, which was a very troublesome process.

Second. Corrosion of exposed wire. No matter how carefully the point where the wire joins the carbon electrode is covered with insulting and protecting material, the coating becomes cracked or broken thus exposing the wire. When this occurs the exposed wire is corroded quite rapidly, being often entirely eaten through before the end of the season. This corrosion also increases the electrical resistance of the wire to a considerable degree.

Third. Poor contact between the electrodes and soil. When the soils of the Rio Grande Valley become dry they crack and if their texture is heavy they crack quite deeply.

Considerable inconvenience was experienced with the electrodes placed three to six inches deep because when the soil became dry it cracked away from the carbons and thus destroyed the electrical connection.

The first two defects might be remedied by more careful workmanship, but there seems to be no way of preventing the third trouble, and this prevents the determination of the minimum moisture content by this method.

The samples at depths 0 to 6 inches and 6 to 12 inches were usually taken with a sampling tube about one and a half inches in diameter. The second foot was taken with an auger.

So much difficulty having been experienced in trying to prevent the loose dry surface soil from falling into the hole while sampling, the use of a guard tube was finally adopted. The guard tube is a piece of brass tubing about one foot long of greater diameter than either the auger or sampling tube and sharpened at one end.

This is forced into the ground a short distance and the samples worked through it. This gives samples mixed with much less of the dry surface soil than had been obtained before.

The results of the first two years showed that it was not necessary to sample more frequently than twice a month, and so the moisture results recorded in this bulletin were taken at about the first and middle of the month.

Since the results obtained by the electrical method were for 3 to 6 and 15 to 18 inches and therefore not strictly comparable with those on the six and twelve inch samples, they are omitted.

All the percentage of moisture in this bulletin are expressed in terms of the dry weight of soil. For example,—25 per cent. of moisture means that for every 100 parts of dry soil there are 25 parts of water.

SOIL

The soil of these plats, like most of the soils of the Mesilla Valley, has been deposited in layers, principally by the river.

It is probable that the soils along the eastern edge of the river bottom land, where these plats are located, have received considerable wash from the foot hills to the east.

The first and second feet are mainly clay loam, passing into loam in some places and into clay in others. The south row, plats 1 to 4, and the two rows on the north, plats 17 to 24, have the heaviest soil. Taking the plats from south to north, we find that with the exception of the plats in the south row, the soil gets heavier in texture toward the north. The east row and west row average rather heavier in texture than the two rows between them.

The third foot varies from loam to clay loam, and in some places there are thin strata of clay.

The fourth foot is, generally, a reddish sand and under this lies a fairly clean sand down to the water table at about 14 feet.

While this is one of the most uniform two acre pieces of land on the station farm, it is variable enough to prevent the results on the different plats from being strictly comparable.

CULTIVATION AND IRRIGATION

The ground was fall ploughed to a depth of about 6 inches in November 1900. Borders were thrown up and the first winter irrigation was given on Dec. 18th, 1900 and the second on Feb. 7th, 1901. In March plats 21 to 24 were sub-soiled to a depth of about 20 inches.

The seed bed was prepared by discing the soil 3 or 4 inches deep and then leveling with the smoothing board. Careful leveling of the surface is essential if water is to be evenly distributed so that every plant may receive its share of the water.

The smoothing board also crushed many clods and, therefore, left the soil in better condition for the reception of the seed.

The corn was planted on April 10th in rows 3 feet 8 inches apart; the hills about 3 feet apart in the rows, with from 3 to 5 kernels in each hill.

The river went dry on April 8th, and the corn could not be irrigated when planted to produce germination, but there proved to be sufficient moisture stored in the soil by the winter irrigation of February 7th to germinate most of the corn, and a fair stand was secured on all the plats except those that were sub-soiled. The sub-soiling followed the winter irrigations, and leaving the soil loose to a considerable depth it dried out badly. Only about one-half a stand of corn was secured on the sub-soiled plats. This result indicates that sub-soiling should be followed by an irrigation before planting.

On May 8th, there again being water for irrigation, all the plats were irrigated and the corn that failed to germinate before came on rapidly.

The plan for irrigation and cultivation was carried out with a few exceptions which will be found recorded in the tables.

One of the purposes of the cultivation was to test the value of a dust mulch in the conservation of moisture during droughty periods. A common corn cultivator was used in cultivating the crop. This implement broke up the soil to a depth of two or three inches, but owing to the heavy texture of the soil, it came up in lumps. No dust mulch was formed and, therefore, the value of this feature of the test was not successfully demonstrated. In fact the moisture tables indicate that the most frequently cultivated plats lost their moisture somewhat more rapidly than the less frequently cultivated ones; hence, in our heavy soils, we should expect other beneficial results to arise from frequent cultivation, such as aeration, admission of heat to the plant roots, etc.

For the crop of 1902 the ground was prepared in about the same way as for that of the previous year. The ground was plowed in December of 1901 and plats 21 to 24 were sub-soiled. It will be noticed that the winter irrigation followed the sub-soiling this year.

Heavy borders were thrown up ready for the winter irrigation but the cleaning of the Main Ditch was not completed until late in the winter. A heavy irrigation was given all the plats on March 12th, except plats 5, 6, 7 and 8.

On April 3rd the surface soil was loosened up two or three inches deep with the Acme harrow and fined with the tooth harrow. The seed bed was in excellent condition. The corn was planted at once about two inches deep with a two-horse corn planter in rows 3 feet 8 inches apart, and the kernels from 12 to 14 inches apart in the rows.

There was no water for irrigation to produce germination when the corn was planted, but on April 23rd water came and all the plats were irrigated. The corn germinated well and made an excellent stand. In fact, the germination was unusually good for our stiff soils, and, therefore, the corn was rather too thick to secure a maximum yield of grain. This, probably, accounts for the smaller yield of grain per acre than was grown in 1901.

A different set of cultivators were used this year in the hope of securing a nearer approach to the desired dust mulch. The cultivation throughout the season was performed with the Planet Jr. plough followed immediately by the Planet Jr. harrow. The surface soil was brought into a somewhat better condition as to fineness but not sufficiently fine to do a great amount of good in conserving moisture. However, on the plats that received the maximum number of irrigations, every ten to fourteen days, cultivation seemingly had a market effect upon the color of the corn during the growing season. Plat 20, that was cultivated every week, kept its normal green color; plat 19, that was cultivated every two weeks, was somewhat yellowish in color; while plat 18, which was cultivated once in four weeks, remained very yellow throughout the growing season.

MOISTURE CONTENT AND CROP CONDITION OF THE PLATS FOR 1901

The following table shows the moisture content of the plats, at 0 to 6, 6 to 12, and 12 to 24 inches, at intervals of about two weeks, from June 29th to Sept. 2nd. It also shows the dates on which the plats were irrigated, the general condition of the crop, the amount of rain which fell between the dates on which the moisture was determined, and the yield of fodder and grain calculated to pounds per acre. The grain was weighed in the ear.

Table 1—Moisture Content and Crop Condition of the Plats for 1901

PLAT 5

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
June 26	....	....	....	....	.46	
June 29	12.5	19.6	16.1	16.1		June 29—Slight wilt July 2—Irrigated July 6—Condition good July 26—Irrigated
July 16	23.8	28.0	20.2	24.0	.80*	
Aug. 5	33.1	30.4	21.4	28.3	1.47	
Aug. 17	24.7	29.2	20.2	24.7	1.18	
Sept. 2	15.2	24.5	16.0	18.6	.06	
Average	**21.9**	**26.3**	**18.8**	**22.3**	....	
Yield....	....	....	....	....	....	Fodder 2008.0 lbs. Grain 1209.8 lbs.

PLAT 6

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	
June 29	15.9	16.5	14.5	15.6		Condition and irrigation as in plat 5
July 16	22.5	23.3	16.9	20.9	.80	
Aug. 5	27.0	25.3	19.1	23.8	1.47	
Aug. 17	25.5	18.1	17.0	20.2	1.18	
Sept. 2	15.6	18.4	13.9	15.9	.06	
Average	**21.3**	**20.3**	**16.3**	**19.3**	....	
Yield....	....	....	....	....	....	Fodder 3022.2 lbs. Grain 1316.6 lbs.

*Rainfall between the dates on which the moisture was determined

Table 1—Moisture Content and Crop Condition of the Plats for 1901
Continued

PLAT 7

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent	6 to 12 in per cent.	12 to 24 in. per cent.			
June 26	....	....	....	....	.46	
June 29	14.2	14.1	15.3	14.8		June 29—Wilting
July 16	12.5	17.2	17.1	15.6	.80	July 6--Beginning to suffer One irrigation
Aug. 5	18.4	20.6	17.1	18.7	1.47	
Aug. 17	16.0	13.9	16.1	15.3	1.18	
Sept. 2	13.1	17.5	13.0	14.5	.06	
Average	**14.8**	**16.6**	**15.9**	**15.8**	....	
Yield....	....	....	....	....	....	Fodder 971.8 lbs Grain 295.5 lbs.

PLAT 8

Date	0 to 6 in. per cent	6 to 12 in per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	
June 29	11.8	17.2	17.8	15.6		Condition as in plat 7 One irrigation.
July 16	14.4	19.3	17.8	17.1	.80	
Aug. 5	20.3	16.1	14.7	17.0	1.47	
Aug. 17	12.1	18.5	17.0	15.9	1.18	
Sept. 2	9.5	17.6	12.7	13.3	.06	
Average	**13.6**	**17.7**	**16.0**	**15.8**	....	
Yield....	....	....	....	....	....	Fodder 1663.0 lbs. Grain 196.9 lbs.

PLAT 9

Date	0 to 6 in. per cent	6 to 12 in per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	June 29—First planting wilting some. Replant wilting considerably
June 29	14.1	21.5	18.1	17.9		
July 16	15.0	16.9	16.0	16.0	.80	July 6—Condition same July 26—Irrigated
Aug. 5	29.5	27.0	24.2	26.9	1.47	
Aug. 17	21.2	22.7	18.0	20.6	1.18	
Sept. 2	15.0	18.2	17.4	16.8	.06	
Average	**19.0**	**21.3**	**18.7**	**19.6**		
Yield....	....	....	....	....	....	Fodder 3696.5 lbs. Grain 1138.1 lbs.

Table I—Moisture Content and Crop Condition of the Plats for 1901—Continued

PLAT 10

Date	Depth 0 t0 6 in. per cent.	 6 to 12 in. per cent.	 12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	
June 29	11.7	13.9	13.0	12.9		June 29—Condition same as plat 9 July 6—Wilting more than plat 9 July 13—Condition good July 20—Condition good July 26—Irrigated
July 16	15.0	14.7	14.7	14.8	.80	
Aug. 5	25.3	27.2	22.5	25.0	1.47	
Aug. 17	16.5	19.4	16.5	17.4	1.18	
Sept. 2	13.0	17.6	13.1	14.9	.06	
Average	**16.3**	**18.6**	**16.0**	**17.0**		
Yield....	....	....	....	....	....	Fodder 3024.1 lbs. Grain 1391.1 lbs.

PLAT 11

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	
June 29	13.5	14.9	16.1	14.8		Condition and irrigation as in plat 9
July 16	10.8	14.8	13.9	13.2	.80	
Aug. 5	23.6	23.0	18.4	21.6	1.47	
Aug. 17	20.0	18.0	16.3	18.1	1.18	
Sept. 2	12.7	20.7	15.3	16.2	.06	
Average	**16.1**	**18.3**	**16.0**	**16.8**		
Yield....	....	....	....	....	....	Fodder 2613.6 lbs. Grain 1240.5 lbs.

PLAT 12

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	
June 29	10.1	17.4	13.4	13.6		Condition and irrigation as in plat 9
July 16	12.7	19.4	14.7	15.6	.80	
Aug. 5	32.4	26.7	18.1	25.7	1.47	
Aug. 17	20.6	23.4	16.2	20.1	1.18	
Sept. 2	19.0	20.0	18.9	18.3	.06	
Average	**19.0**	**21.4**	**15.6**	**18.6**		
Yield....	....	....	....	....	....	Fodder 3459.0 lbs. Grain 1703.7 lbs.

Table 1—Moisture Content and Crop Condition of the Plants for 1901
Continued

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
PLAT 13						
June 26	....	....	....	....	.46	June 29 — First planting wilting some. Replant wilting considerably July 2—Irrigated July 6—No wilt July 26—Irrigated
June 29	13.2	19.6	15.6	16.1		
July 16	24.9	23.0	20.0	22.6	.80	
Aug. 5	22.1	26.9	21.2	23.4	1.47	
Aug. 17	19.9	22.9	16.7	19.8	1.18	
Sept. 2	17.6	19.2	19.6	18.1	.06	
Average	**19.5**	**22.3**	**18.2**	**20.0**		
Yield....	....	....	....	....	....	Fodder 4216.7 lbs. Grain 2098.5 lbs.
PLAT 14						
June 26	....	....	....	....	.46	Condition and irrigation same as in plat 13
June 29	12.5	15.2	15.5	14.4		
July 16	21.9	24.7	18.2	21.6	.80	
Aug. 5	20.3	26.3	22.7	23.1	1.47	
Aug. 17	17.4	20.5	18.2	18.7	1.18	
Sept. 2	18.2	21.0	14.4	17.8	.06	
Average	**18.1**	**21.5**	**17.8**	**19.1**		
Yield....	....	....	....	....	....	Fodder 4122.1 lbs. Grain 2093.7 lbs
PLAT 15						
June 26	....	....	....	....	.46	Condition and irrigation same as in plat 13
June 29	13.4	13.2	10.7	12.4		
July 16	25.9	22.9	15.5	21.4	.80	
Aug. 5	27 7	27.7	20.0	28.1	1.47	
Aug. 17	17.6	19.0	15.9	17.5	1.18	
Sept. 2	13.1	16.7	12.8	14.2	.06	
Average	**19.5**	**19.9**	**15.0**	**18.1**		
Yield....	....	....	....	....	....	Fodder 4663.5 lbs. Grain 1418.2 lbs.

Table 1—Moisture Content and Crop Condition of the Plats for 1901
Continued

PLAT 16

Date	Depth 0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in	Rain inches	Remarks
June 26	....	....	....	....	.46	Condition and irrigation same as in plat 13
June 29	13.7	21.7	18.2	17.9	.80	
July 16	27.2	27.8	23.5	26.1	1.47	
Aug. 5	21.9	28.8	23.0	23.6	1.18	
Aug. 17	21.0	19.2	21.0	20.4	.06	
Sept. 2	16.9	19.1	16.2	17.4		
Average	**20.1**	**22.7**	**20.4**	**21.1**		
Yield....	....	....	....	....	....	Fodder 5530.5 lbs. Grain 2540.2 lbs.

PLAT 17

Date	Depth 0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in	Rain inches	Remarks
June 26	....	....	....	....	.46	June 29—First planting, no wilt. Replant wilting slightly. July 2—Irrigated July 6—No wilt July 13—Color yellowish July 16—Irrigated July 30—Irrigated
June 29	22.6	29.7	26.1	26.1	.80	
July 16	23.7	28.3	23.5	25.2	1.47	
Aug. 5	22.5	27.2	23.3	24.3	1.18	
Aug. 17	21.5	25.3	24.0	23.6	.06	
Sept. 2	20.2	25.0	18.0	21.1		
Average	**22.1**	**27.1**	**23.0**	**24.1**		
Yield....	....	....	....	....	....	Fodder 5955.6 lbs. Grain 2362.7 lbs.

PLAT 18

Date	Depth 0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in	Rain inches	Remarks
June 26	....	....	....	....	.46	Irrigation same as plat 17 June 29—Replant wilting slightly. Color yellowish July 6—No wilt July 13—Decidedly yellowish
June 29	20.5	25.9	23.3	23.2	.80	
July 16	23.3	23.1	20.8	22.4	1.47	
Aug. 5	27.6	28.8	23.5	26.6	1.18	
Aug. 17	22.6	22.9	19.1	21.5	.06	
Sept. 2	14.9	19.6	15.2	16.6		
Average	**21.8**	**24.1**	**20.4**	**22.1**		
Yield....	....	....	....	....	....	Fodder 5411.5 lbs. Grain 1877.1 lbs.

Table 1—Moisture Contdnt and Crop Condition of the Plats for 1901

Continued

PLAT 19

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24in. per cent.			
June 26	....	....	....	....	.46	Irrigation same as plat 17 June 29—Condition as in plat 17 July 6—No wilt. Color slightly yellowish
June 29	22.0	22.0	22.5	22.2		
July 16	21.0	24.7	18.8	21.5	.80	
Aug. 5	30.3	30.9	24.5	28.5	1.47	
Aug. 17	21.4	19.4	17.0	19.2	1.18	
Sept. 2	15.5	22.6	15.5	17.8	.06	
Average	**22.0**	**23.9**	**19.7**	**21.8**		
Yield....	....	....	....	....	....	Fodder 3898.3 lbs. Grain 1811.4 lbs

PLAT 20

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	Irrigated same as plat 17 June 29—Condition same as in plat 17 July 6—No wilt July 20—No wilt
June 29	18.5	19.9	11.7	16.7		
July 16	18.4	22.6	20.2	20.4	.80	
Aug. 5	21.2	21.0	17.5	19.9	1.47	
Aug. 17	18.7	20.3	18.7	19.2	1.18	
Sept. 2	11.4	16.9	14.8	14.4	.06	
Average	**17.6**	**20.1**	**16.6**	**18.1**		
Yield....	....	....	....	....	....	Fodder 1847.6 lbs. Grain 3428.5 lbs.

PLAT 21

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	June 29—First planting wilting considerably. Replant wilting more July 2—Irrigated July 6—No wilt July 26—Irrigated
June 29	14.4	22 0	19.0	18.5		
July 16	18.1	21.9	16.3	18.8	.80	
Aug. 5	22.1	25.4	23.0	23.5	1.47	
Aug. 17	14.5	21.4	13.2	16.3	1.18	
Sept. 2	11.5	17.2	15.2	14.6	.06	
Average	**16.1**	**21.6**	**17.3**	**18.3**		
Yield....	....	....	....	....	....	Fodder 2695 7 lbs. Grain 988.6 lbs.

Table I—Moisture Content and Crop Condition of the Plats for 1901

Continued

PLAT 22

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in per cent.			
June 26	....	....	....	....	.46	Irrigated like plat 21
June 29	11.2	23.7	22.1	19.0		June 29—Condition same as plat 21
July 16	20.5	22.7	23.0	22.0	.80	July 6—Slight wilt *
Aug. 5	25.3	29.7	26.6	27.2	1.47	
Aug. 17	23.5	23.3	22.5	23.1	1.18	
Sept. 2	13.1	19.2	16.9	16.4	.06	
Average	**18.7**	**23.7**	**22.2**	**21.5**		
Yield....	....	....	....	....	....	Fodder 2568.0 lbs. Grain 1303 0 lbs.

PLAT 23

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	Same as plat 21
June 29	13.0	19.0	23.1	18.3		
July 16	28.7	28 7	23.7	27.0	.80	
Aug. 5	26 4	28.5	27.7	27.8	1.47	
Aug. 17	22.6	24.5	21.0	22.7	1.18	
Sept. 2	18.7	20.4	16.2	18.4	.06	
Average	**21.9**	**24.2**	**22.3**	**22.8**		
Yield....	....	....	....	....	....	Fodder 4953.7 lbs. Grain 2285.8 lbs.

PLAT 24

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
June 26	....	....	....	....	.46	Same as plat 21
June 29	12.6	22.1	24.5	19.7		
July 16	25.6	27.4	26.3	26.4	.80	
Aug. 5	25.8	29.5	24.2	26.5	1.47	
Aug. 17	22.6	18.8	19.0	20.1	1.18	
Sept. 2	18.1	24.0	20.3	20.8	.06	
Average	**20.9**	**24.3**	**22.9**	**22.7**		
Yield....	....	....	....	....	....	Fodder 5460.3 lbs. Grain 2058.1 lbs.

*Had not recovered from the effects of the drouth.

MOISTURE CONTENT AND CROP CONDITION OF THE PLATS FOR 1902

Table 2 gives the amount of moisture, irrigation, rainfall, and yield for 1902 arranged as in Table 1.

It is not thought necessary to discuss in detail, data given in Tables 1 and 2, as the results will be discussed under other headings.

Table 2—Moisture Content and Crop Condition of the Plats for 1902

PLAT 1

Date	Depth			Average per cent. 9 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	10 to 24 in. per cent.			
April 14	16.2	25.0	18.5	19.9		April 23—Irrigated
May 1	21.0	28.3	21.4	23.6		
May 14	21.0	27.8	23.1	23.9		
May 28	12.6	22.6	20.3	18.8		
June 12	14.5	20.8	19.1	18.1		
June 30	11.2	16.2	19.2	15.5	.00	
July 14	17.0	16.5	15.2	16.2	.72	
July 31	14.8	17.4	12.8	15.0	1.44	
Aug. 15	39.2	29.5	25.6	31.4	4.22	
Sept. 1	25.4	29.2	22.9	25.8	2.32	
Average	**19.3**	**23.3**	**19.8**	**20.8**		
Yield....	....	....	....	....	....	Fodder 1119.7 lbs. Grain 209.9 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902
Continued

PLAT 2

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	20.5	21.4	21.4	21.1		Irrigation as in plat 1
May 1	16.9	21.6	23.0	22.2		
May 14	22.6	24.7	23.7	23.6		
May 28	18.5	13.1	18.4	16.6		
June 12	11.6	18.2	22.0	17.2		
June 30	8.4	13.5	14.8	12.2	.00	
July 14	16.6	14.4	16.2	15.7	.72	
July 31	15.8	12.8	13.7	14.1	1.44	
Aug. 15	42.0	34.9	26.3	34.4	4.22	
Sept. 1	26.3	25.6	23.7	25.2	2.32	
Average	**19.9**	20.5	**20.3**	**20.2**		
Yield....	....	....	....	....	....	Fodder 1683.5 lbs. Grain 242.4 lbs.

PLAT 3

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	19.3	25.3	16.2	20.3		April 23—Irrigated June 20—Irrigated July 28—Irrigated
May 1	28.2	28.3	22.3	26.3		
May 14	31.9	30.5	24.7	29.0		
May 28	17.8	22.9	20.5	20.4		
June 12	11.4	21.0	20.0	17.4		
June 30	22.3	22.5	16.1	20.3	.00	
July 14	19.1	17.5	18.5	18.3	.72	
July 31	38.7	29.7	22.9	30.4	1.44	
Aug. 15	48.3	36.8	26.6	37.2	4.22	
Sept. 1	30.2	28.3	20.2	26.2	2.32	
Average	**26.7**	**26.3**	**20.8**	**24.6**		
Yield....	....	....	....	....	....	Fodder 2120.5 lbs. Grain 1170.9 lbs.

Note—June 20, small plants on all the plats wilting slightly.

Table 2—Moisture Content and Crop Condition of the Plats for 1902

Continued

PLAT 4

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	0 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	24.3	32.9	24.0	27.0		Irrigation same as plat 3
May 1	28.5	30.9	25.0	28.1		
May 14	30.0	41.6	29.2	33.6		
May 28	18.0	27.7	22.3	22.6		
June 12	14.5	22.6	20.8	19.3		
June 30	26.3	26.9	19.6	24.3	.00	
July 14	24.0	25.3	21.5	23.6	.72	
July 31	41.2	34.4	22.0	32.5	1.44	
Aug. 15	46.4	40.2	24.3	37.0	4.22	
Sept. 1	30.5	31.9	22.3	28.2	2.32	
Average	**28.4**	**31.4**	**23.1**	**27.6**		
Yield....	....	....	....	....	....	Fodder 1857.1 lbs. Grain 771.4 lbs

PLAT 5

Date	0 to 6 in. per cent.	0 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	18.9	22.7	13.1	18.2		April 23–Irrigated June 20— " July 28— " June 20—Curling badly Condition good for remainder of season Not winter irrigated
May 1	35.5	32.2	28.7	32.1		
May 14	27.6	37.7	37.1	34.1		
May 28	21.5	24.5	22.6	22.8		
June 12	10.6	12.1	20.5	14.4		
June 30	23.6	25.0	19.0	22.5	.00	
July 14	21.7	24.3	17.4	21.1	.72	
July 31	42.0	30.5	23.3	31.1	1.44	
Aug 15	49.4	36.6	25.2	37.0	4.22	
Sept. 1	31.9	31.2	28.6	28.6	2.32	
Average	**28.3**	**27.7**	**22.9**	**26.3**		
Yield....	....	....	....	....	....	Fodder 5180.7 lbs. Grain 1917.6 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902
Continued

PLAT 6

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	12.6	19.9	16.9	16.4		Irrigation and condition same as plat 9
May 1	29.5	30.2	23.7	27.8		
May 14	22.0	28.8	23.5	24.8		
May 28	17.1	23.1	21.0	20.4		
June 12	10.7	18.2	17.4	15.4		
June 30	24.2	22.9	16.9	21.3	.00	
July 14	24.9	18.7	16.0	19.8	.72	
July 31	34.4	29.2	23.6	29.1	1.44	
Aug. 15	49.7	32.9	27.8	36.8	4.22	
Sept. 1	26.9	26.9	22.6	25.5	2.32	
Average	**25.2**	**25.1**	**20.9**	**23.7**		
Yield....	....	....	....	....	....	Fodder 4266.6 lbs. Grain 1800.0 lbs.

PLAT 7

Date	0 to 6 in. per cent	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	14.1	18.0	18.0	16.7		Irrigation and condition same as plat 5
May 1	27.0	26.9	25.6	26.5		
May 14	25.0	31.9	25.4	27.4		
May 28	17.2	24.3	25.3	22.2		
June 12	13.7	20.8	22.3	18.9		
June 30	23.8	22.0	22.9	22.9	.00	
July 14	15.0	13.9	15.0	14.6	.72	
July 31	32.4	29.4	26.6	29.5	1.44	
Aug. 15	37.9	35.5	30.0	34.5	4.22	
Sept. 1	27.8	24.3	21.4	24.5	2.32	
Average	**23.4**	**24.7**	**23.2**	**23.7**		
Yield....	....	....	....	....	....	Fodder 5201.0 lbs. Grain 839.0 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902

Centinued

PLAT 8

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	16.7	21.4	14.2	17.4		Irrigation and condition same as plat 5
May 1	25.9	28.5	23.5	25.9		
May 14	20.5	25.2	23.6	23.1		
May 28	13.6	21.4	19.9	18.3		
June 12	13.6	20.6	22.5	18.9		
June 30	25.9	28.0	24.2	26.0	.00	
July 14	20.8	18.1	17.0	18.6	.72	
July 31	33.6	32.6	23.8	30.0	1.44	
Aug. 15	33.6	36.2	31.7	33.8	4.22	
Sept. 1	26.9	28.2	24.2	26.4	2.32	
Average	23.1	26.2	22.4	23.8		
Yield....	....	....	....	....	....	Fodder 5033.0 lbs. Grain 820.5 lbs.

PLAT 9

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	19.9	27.7	26.1	24.6		April 23—Irrigated Aug 1--Irrigated
May 1	25.0	31.0	29.5	28.5		
May 14	20.2	29.0	29.4	26.2		
May 28	15.5	23.7	26.6	21.9		
June 12	10.0	17.6	22.5	16.7		
June 30	10.5	20.0	21.0	17.1	.00	
July 14	19.4	15.9	16.3	17.2	.72	
July 31	16.6	18.4	18.4	17.8	1.44	
Aug. 15	39.4	36.0	34.9	31.6	4.22	
Sept. 1	27.4	29.7	25.4	27.5	2.32	
Average	20.4	24.9	25.0	23.4		
Yield....	....	....	....	....	....	Fodder 2646.0 lbs. Grain 291.8 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902
Continued

PLAT 10

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	15.5	25.0	21.5	20.6		April 23—Irrigated Aug. 1—Irrigated
May 1	24.0	29.2	23.3	25.5		
May 14	26.9	28.8	27.0	27.6		
May 28	16.9	21.0	24.3	20.7		
June 12	15.9	16.2	22.7	18.3		
June 30	7.0	12.8	10.2	10.0	.00	
July 14	14.7	13.0	13.7	13.4	.72	
July 31	14.9	13.6	15.5	14.6	1.44	
Aug. 15	38.1	37.7	30.0	35.2	4.22	
Sept. 1	26.3	30.5	24.2	27.0	2.32	
Average	20.0	22.8	21.2	21.3		
Yield....	....	....	....	....	....	Fodder 3145.0 lbs. Grain 534.2 lbs.
PLAT 11						
April 14	17.8	22.9	22.5	21.1		April 23—Irrigated Aug. 1—Irrigated
May 1	21.9	27.2	23.0	24.0		
May 14	21.4	25.9	23.6	23.6		
May 28	13.1	19.3	20.5	17.6		
June 12	12.8	19.0	18.2	16.6		
June 30	9.9	13.6	13.4	12.3	.00	
July 14	13.4	14.4	12.4	13.4	.72	
July 31	15.2	14.9	12.5	14.2	1.44	
Aug. 15	37.4	32.2	28.0	31.6	4.22	
Sept. 1	24.2	27.2	24.5	25.3	2.32	
Average	18.4	21.7	19.9	20.0		
Yield....	....	....	....	....	....	Fodder 2272.7 lbs. Grain 331.4 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902

Continued

PLAT 12

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	9 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	21.2	28.5	20.2	23.3		April 23—Irrigated Aug. 1—Irrigated
May 1	24.2	28.5	24.3	25.6		
May 14	22.5	27.6	20.8	23.6		
May 28	16.9	24.0	21.0	20.6		
June 12	15.8	19.0	18.7	17.8		
June 30	12.4	20.3	15.3	16.0	.00	
July 14	18.4	21.0	17.5	18.9	.72	
July 31	18.2	19.3	15.6	17.7	1.44	
Aug. 15	45.3	38.9	26.4	36.9	4.22	
Sept. 1	31.7	30.9	22.7	28.4	2.32	
Average	**22.6**	**25.8**	**20.3**	**22.9**		
Yield....	....	....	....	....	....	Fodder 2911.0 lbs. Grain 813.3 lbs.

PLAT 13

Date	0 to 6 in. per cent.	9 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	18.5	28.7	22.5	23.2		April 23—Irrigated June 20—Irrigated July 28—Irrigated
May 1	23.1	36.4	23.8	22.7		
May 14	20.5	30.0	23.7	24.7		
May 28	17.8	26.6	22.9	22.4		
June 12	11.8	16.9	15.8	14.8		
June 30	20.8	24.7	20.8	22.1	.00	
July 14	24.2	22.7	18.8	21.9	.72	
July 31	30.7	32.9	25.9	29.8	1.44	
Aug. 15	37.3	37.0	33.1	35.8	4.22	
Sept. 1	24.9	28.2	24.3	25.8	2.32	
Average	**23.0**	**28.4**	**23.2**	**24.8**	....	
Yield....	....	....	....	....	....	Fodder 3448.2 lbs. Grain 1665.0 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902 Continued

PLAT 14

Date	Depth 0 to 6 in per cent.	6 to 12 in per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	20.2	28.8	23.7	24.2		Irrigated like plat 13
May 1	28.2	29.5	23.1	26.9		
May 14	22.6	26.9	25.3	24.9		
May 28	17.6	22.3	21.7	20.5		
June 12	11.5	19.6	19.1	16.7		
June 30	21.4	25.3	21.4	22.7	.00	
July 14	20.2	15.0	14.7	16.6	.72	
July 31	30.2	30.9	24.7	28.6	1.44	
Aug. 15	36.2	33.6	28.2	32.6	4.22	
Sept. 1	26.9	28.2	25.0	26.7	2.32	
Average	23.5	26 0	22.7	24.1	....	
Yield....	....	....	....	....	....	Fodder 3773.0 lbs. Grain 1445.0 lbs.

PLAT 15

Date	Depth 0 to 6 in per cent.	6 to 12 in per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	19.3	27.7	21.4	22.8		Irrigated like plat 13
May 1	29.2	30.5	25.6	28.4		
May 14	26.3	28.8	23.1	26.1		
May 28	17.4	24.0	24.7	22.0		
June 12	12.1	15.6	13.4	13.7		
June 30	22.3	24.5	18.8	21.8	.00	
July 14	19.3	21.4	15.2	18.6	.72	
July 31	31.2	34.4	28.5	31.4	1.44	
Aug. 15	38.9	33.4	27.2	33.2	4.22	
Sept. 1	25.3	22.6	20.2	22.7	2.32	
Average	24.1	26.3	21.8	24.1	....	
Yield....	....	....	....	....	....	Fodder 4756.3 lbs Grain 1131.0 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902

Continued

PLAT 16

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent			
April 14	17.1	29.8	25.4	24.1		Irrigated like plat 13
May 1	31.2	32.9	25.9	30.0		
May 14	23.5	30.9	32.9	29.1		
May 28	18.0	29.5	25.3	24.3		
June 12	12.1	22.5	26.9	20.5		
June 30	23.3	26.4	24.5	24.7	.00	
July 14	19.6	21.0	18.5	19.7	.72	
July 31	30.4	29.2	24.9	28.1	1.44	
Aug. 15	40.8	35.9	31.7	36.1	4.22	
Sept. 1	32.4	33.1	22.3	29.2	2.32	
Average	**24.8**	**29.1**	**25.8**	**26.6**	....	
Yield....	....	....	....	....	....	Fodder 4951.6 lbs Grain 1238.0 lbs.

PLAT 17

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	18.1	31.9	28.7	26.2		April 23—Irrigated May 14— " June 2— " June 19— " July 8— " July 28— "
May 1	32.6	30.9	31.9	31.9		
May 14	29.5	33.0	30.2	30.9		
May 28	25.6	32.2	28.8	28.8		
June 12	22.1	35.7	31.2	29.6		
June 30	21.0	29.0	24.2	24.7	.00	
July 14	41.8	34.6	27.7	34.7	.72	
July 31	40.0	35.3	28.7	34.7	1.44	
Aug. 15	47.5	38.1	31.2	38.9	4.22	
Sept. 1	41.2	36.2	29.4	35.6	2.32	
Average	**31.9**	**33.8**	**29.1**	**31.6**	....	
Yield....	....	....	....	....	....	Fodder *5385.4 lbs. Grain 1906.0 lbs.

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*The fodder from plat 17 contained considerable sorghum

Table 2—Moisture Content and Crop Condition of the Plats for 1902
Continued

PLAT 18

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	19.9	28.2	25.4	24.5		Irrigated like plat 17
May 1	31.2	31.2	29.5	30.6		
May 14	25.0	29.8	28.5	27.8		
May 28	27.6	30.5	29.5	28.4		
June 12	26.4	29.7	28.0	28.0		
June 30	22.6	21.2	24.5	22.7	.00	
July 14	41.6	35.1	29.8	35.5	.72	
July 31	37.0	31.2	24.3	30.8	1.44	
Aug. 15	45.8	39.2	31.2	38.7	4.22	
Sept. 1	39.2	29.5	26.9	31.8	2.32	
Average	**31.6**	**30.6**	**27.7**	**29.9**	....	
Yield....	....	....	....	....	....	Fodder 5050.7 lbs. Grain 2175.8 lbs.

PLAT 19

Date	0 to 6 in per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	19.6	28.5	24.9	24.3		Irrigated like plat 17
May 1	26.4	30.5	28.2	28.3		
May 14	22.5	30.2	27.8	26.8		
May 28	25.9	29.5	23.1	26.2		
June 12	26.9	31.9	26.4	28.4		
June 30	19.8	18.8	23.1	20.6	.00	
July 14	38.4	34.7	28.5	33.9	.72	
July 31	35.3	32.2	24.7	30.7	1.44	
Aug. 15	39.8	34.4	30.9	35.0	4.22	
Sept. 1	37.5	28.8	22.9	29.7	2.32	
Average	**29.2**	**30.0**	**26.0**	**28.4**	....	
Yield....	....	....	....	....	....	Fodder 4745.7 lbs. Grain 2245.7 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902
Continued.

PLAT 20

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	17.5	27.8	23.7	23.0		Irrigated like plat 17
May 1	27.4	28.2	23.0	26.2		
May 14	25.0	31.9	27.8	28.2		
May 28	25.0	28.8	22.9	25.6		
June 12	24.3	28.7	24.3	25.8		
June 30	17.6	23.6	20.8	20.8	.00	
July 14	36.2	32.9	27.4	32.2	.72	
July 31	34.4	32.9	26.7	31.3	1.44	
Aug. 15	43.2	41.0	36.4	40.2	4.22	
Sept. 1	32.2	28.3	24.5	28.3	2.32	
Average	**28.3**	**30.4**	**25.7**	**28.1**	....	
Yield....	....	....	....	....	....	Fodder 4209.5 lbs. Grain 2033.3 lbs.

PLAT 21

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	17.1	31.6	29.5	24.8		April 23—Irrigated June 20—Irrigated July 28—Irrigated
May 1	22.1	30.7	25.8	26.7		
May 14	23.3	31.9	30.2	28.4		
May 28	16.2	28.2	21.0	21.8		
June 12	11.0	20.5	17.5	16.3		
June 30	17.4	28.8	20.0	22.1	.00	
July 14	23.6	26.1	24.5	24.7	.72	
July 31	34.4	32.9	26.7	31.3	1.44	
Aug. 15	41.4	38.7	28.7	36.2	4.22	
Sept. 1	34.0	34.0	26.7	31.6	2.32	
Average	**24.0**	**30.3**	**24.7**	**26.3**	....	
Yield....	....	....	....	....	....	Fodder 3131.8 lbs. Grain 1268.5 lbs.

Table 2 -Moisture Content and Crop Condition of the Plats for 1902
Continued

PLAT 22

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent			
April 14	19.6	33.4	24.5	25.8		Irrigated like plat 21
May 1	25.3	31.7	26.3	27.8		
May 14	19.1	32.6	28.8	26.8		
May 28	17.1	31.6	27.2	25.3		
June 12	12.7	22.7	21.9	19.1		
June 30	23.5	25.8	23.5	24.2	.00	
July 14	16.7	19.9	21.9	19.5	.72	
July 31	38.7	38.9	28.0	35.2	1.44	
Aug. 15	44.5	36.2	29.7	36.8	4.22	
Sept. 1	33.3	32.4	25.4	30.3	2.32	
Average	**25.0**	**30.5**	**25.7**	**27.1**	....	
Yield....	....	....	....	....	....	Fodder 3416.7 lbs. Grain 1115.3 lbs.

PLAT 23

Date	0 to 6 in. per cent.	6 to 12 in. per cent.	12 to 24 in. per cent	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	24.3	32.4	28.8	28.5		Irrigated like plat 21
May 1	26.9	31.2	23.7	27.3		
May 14	22.9	30.5	29.4	27.6		
May 28	20.8	30.9	29.5	27.0		
June 12	12.5	20.5	21.4	18.1		
June 30	28.2	29.4	22.9	26.8	.00	
July 14	18.0	24.3	24.2	22.2	.72	
July 31	33.8	33.6	28.3	31.9	1.44	
Aug. 15	46.6	39.2	33.4	39.7	4.22	
Sept. 1	43.6	32.2	25.4	33.7	2.32	
Average	**27.7**	**30.4**	**26.7**	**28.3**	....	
Yield....	....	....	....	....	....	Fodder 5115.7 lbs. Grain 1209.5 lbs.

Table 2—Moisture Content and Crop Condition of the Plats for 1902
Continued

PLAT 24

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	0 to 6 in. per cent.	1 to 12 in. per cent.	12 to 24 in. per cent.			
April 14	24.0	32.9	32.1	29.6		Irrigated like plat 21
May 1	28.3	34.0	31.6	31.9		
May 14	26.3	33.3	29.8	29.8		
May 28	14.7	29.8	30.5	25.0		
June 12	9.7	32.2	29.5	23.8		
June 30	26.9	32.9	27.2	29.0	.00	
July 14	28.3	25.6	26.4	26.8	.72	
July 31	39.2	37.7	32.4	36.4	1.44	
Aug. 15	42.8	42.4	33.6	39.6	4.22	
Sept. 1	43.0	33.8	30.2	35.6	2.32	
Average	**28.3**	**33.5**	**30.3**	**30.7**	....	
Yield....	....	....	....	....	....	Fodder 4846.5 lbs. Grain 1222.2 lbs.

PLAT 25; a, b, c and d

Date	0 to 6 in. per cent.	1 to 12 in. per cent.	12 to 24 in. per cent.	Average per cent. 0 to 24 in.	Rain inches	Remarks
April 14	18.4	29.4	25.9	24.6		April 28—Irrigated
May 1	26.7	31.8	30.0	29.5		
May 14	19.6	29.4	27.7	25.6		
May 28	15.1	21.8	24.8	20.6		
June 12	12.7	21.2	20.0	17.9		
June 30	10.9	17.9	16.2	15.0	.00	
July 14	15.6	18.3	15.7	16.5	.72	
July 31	16.4	15.7	14.3	15.5	1.44	
Aug. 15	35.8	33.0	27.0	31.9	4.22	
Sept. 1	32.4	28.5	25.1	28.6	2.32	
Average	**20.4**	**24.7**	**22.7**	**22.6**		
Yield....	....	....	....	....	....	Fodder 1797.4 lbs. Grain 495.0 lbs.

Table 2--Moisture Content and Crop Condition of the Plats for 1902
Continued

PLAT 26; a, b, c and d

Date	Depth			Average per cent. 0 to 24 in.	Rain inches	Remarks
	6 to 6 in. per cent.	6 to 12 in. per cent.	12 to 25 in. per cent.			
April 14	15.8	25.6	21.9	21.1		April 28—Irrigated
May 1	24.0	29.3	23.5	25.6		
May 14	19.4	27.2	26.1	24.2		
May 28	15.9	24.5	23.2	21.2		
June 12	11.1	22.3	21.5	18.3	.00	
June 30	9.4	19.5	15.9	14.9	.72	
July 14	13.9	17.9	18.1	16.6	1.44	
July 31	17.3	18.4	18.0	17.9	4.22	
Aug. 15	41.3	35.7	29.9	35.6	2.32	
Sept. 1	38.4	31.6	28.1	32.7		
Average	20.7	25.2	22.6	22.8		
Yield....	....	....	....	....	....	Fodder 2512.6 lbs. Grain 631.8 lbs.

RELATION OF MEXICAN METHOD TO OTHER METHODS OF IRRIGATION

The dates on which these plats were irrigated are shown in tables 1 and 2.

From table 3, it will be found that in 1901 the plats receiving the three irrigations yielded at the rate of 4633.2 lbs. (2.3 tons) of fodder and 2037.6 lbs. (28.3 bushels) of corn in the ear. The plats receiving fewer irrigations did not yield so much, while those receiving four irrigations produced about 40 lbs. more fodder and 63 lbs. less grain.

Table 4 shows that in 1902 the plats not sub-soiled and receiving three irrigations yielded at the rate of 4232.3 lbs. (2.1 tons) of fodder per acre, and 1369.7 lbs. (19 bushels) of corn in the ear. The plats receiving fewer irrigations gave only about half as much fodder and nearly one third less grain, while those receiving six irrigations gave more fodder (4847.8 lbs.) and about one third more grain (2090.2 lbs.).

This slight difference in yield between the plats receiving three irrigations and those receiving six, is probably due to the heavy rainfall in August, (See table 2) which raised moisture content of those receiving three irrigations considerable above what it would have been with the normal rainfall of that month.

From the results of the two years, we conclude that at least one to three more irrigations may be given with advantage to corn, when the water supply is abundant, and cheap enough, than is usually the custom in the Mesilla Valley.

NUMBER OF IRRIGATIONS, AMOUNT OF MOISTURE AND YIELD OF CORN

Year 1901.—No moisture determinations at 0 to 6, 6 to 12, and 12 to 24 inches were made on the two strips 25 and 26, but their moisture content, judging from the results in 1902 could be fairly assumed to be about one to two per cent. higher than that of plats 7 and 8, which would give an average for the four plats of about 17 per cent. in the first two feet.

From table 3 we find that this 17 per cent. is only one per cent. less than the average of the plats which received two irrigations, yet those having two irrigations produced two and a half times as much fodder and four times as much corn as those receiving one. The reasons for this great difference in yield we find in the distribution of the moisture as shown in table 1.

By June 29th, plats 7 and 8 were beginning to suffer for moisture the soil containing 14.8 in one and 15.6 per cent. in the other in the first two feet. Plats 9 to 12 had rather less moisture than 7 and 8 at this time, 14.8 per cent. in the first two feet, and were showing the need of water, especially the younger, replanted corn. On July 16th the moisture condition was better especially in the first foot, due to .8 inch of rain since June 29th, but the crop was still suffering.

The irrigation given plats 9 to 12 on July 26th, together with the 2.71 inches of rain during the remainder of the season enabled the crop to make considerable growth, but it was unable to overcome the effect of the previous drought conditions. Plats 7 and 8 received only the rain and while this enabled them to make some growth, yet they were never much above the drought limit.

Plats 25 and 26 having a heavier soil, and retaining more moisture than plats 7 and 8 were able to endure the lack of water somewhat better.

Plats 13 to 16 which received three irrigations contained an average of 19.6 per cent. of moisture for the season. Table 1 shows that while they had begun to suffer by June 29th, the moisture being about as low as in the plats discussed above (15.2 per cent. in the first two feet), the irrigation on July 2nd raised the moisture content to an average of 22.9 per cent. in the first two feet of soil, which placed them well beyond danger from drought. The rain, together with the irrigation on July 26th kept them in good condition for the remainder of the season, although some of them were getting rather dry by September 2nd.

Plats 17 to 20, the soil being heavier and more retentive of moisture than that of the plats already discussed, were not showing as much drought effect on June 29th as were the others, and the three subsequent irrigations, with the rain, kept their soil quite moist. On June 29th, plats 18 to 20 were showing a yellowish tinge and this continued for several weeks, being especially noticeable on July 6th. This probably indicated too much water in this heavy soil. The average moisture content in the first two feet for the season was 21.5 per cent.

From table 3 it will be observed that the average moisture content increases with the number of irrigations, as does the yield, but when we consider the moisture content and yield of the individual plats, we find very little if any connection between them.

Year 1902.—The plats receiving one irrigation, besides the winter irrigation, this season contained one-tenth per cent. more moisture than did those receiving four irrigations in 1901. Their yield, however, is only about 500 lbs. more fodder and 50 lbs. more grain than those receiving one irrigation in 1901, and is only about one-third of fodder and one-fifth in grain of the yield of the plats receiving four irrigations in 1901. (See table 4) Plat 1 was apparently in a drougthy condition, as is shown in table 2, from about June 12th to August 6th, (when 1.79 inches of rain fell) averaging 16.4 per cent. of moisture, and plat 2 from May 28th to August 6th, averging 15.2 per cent. Plat 25 averaging about 16 per cent. from June 12th to August 6th, while plat 26 averaged about 17 per cent. during the same period. This droughty condition during the early growing season is apparently sufficient to account for the small yield. The August rains (6.54 inches) while they wet the soil very thoroughly, and consequently raised the average moisture content for the season, apparently came too late to overcome the effect of the droughth.

Plats 9 to 12, which received two irrigations besides the winter irrigations, only contained an average of 21.9 per cent. of moisture for the season and produced an average of about 1000 lbs. more of fodder and 100 lbs. more of corn than the plats that received one irrigation. These plats were as dry from June 12th to August 1st as those receiving one irrigation and the irrigation of August 1st was only five days before the rains began; so that it is questionable whether the irrigation alone accounts for the increased yield, especially since there is so much variation in the yields of the different plats of this series.

Plats 13 to 16 were winter irrigated, but not sub-soiled, and received three irrigations. Their average moisture content for the season was 24.9 per cent., varying from 24.1 to 26.6 per cent., their average yield was 4232.3 lbs. (2.1 tons) of fodder and 1369.7 lbs. (19.5 bushels) of corn. On June 12th several of these plats were rather dry but there seems to be no well defined relation between this drought period and the yield, plat 15 reached an average of 13.7 per cent. on that date and give about 200 lbs. less fodder and 100 lbs. less corn than plat 16 which averaged 20.5 per cent., while plat 13 averaging

14.8 per cent. gave about 1500 lbs. less fodder and 400 lbs. more grain than plat 16.

With the exception of this date, all these plats were in favorable moisture condition throughout the season.

Plats 17 to 20, which received six irrigations in addition to the winter irrigation, contained the maximum average percentage of moisture 29.5 and gave the maximum yield of grain, 2090.2 lbs. (29 bushels).

We find for this season as in 1901 that the yield is proportional to the number of irrigations, but bears very little relation to the average moisture content for the season, as determined in these experiments.

Table 3 contains data on the relation of the number of irrigations to the moisture content of the soil and the yields of fodder and corn for 1901.

The sizes of the plats being somewhat variable, the yield of fodder is calculated to pounds per acre and the grain is calculated to pounds and bushels per acre, allowing 70 lbs. of corn in the ear to the bushel.

The first irrigation on all the plats was given when the corn was germinating.

Table 3--Relation of Number of Irrigations to Moisture and Yield for 1901

Plat No.	Average Moisture content in 0–24 in. per cent.	Yield		
		Fodder	Grain	
		Lbs. per acre	Lbs. per acre	Bushels per acre
		ONE IRRIGATION		
7	15.8	971.8	295.5	4.2
8	15.8	1663.0	196.9	2.8
25	....	1381.7	607.2	8.6
26	....	836.5	281.3	4.0
Average	....	**1213.2**	**345.2**	**4.9**
		TWO IRRIGATIONS		
9	19.6	3696.5	1138.1	16.2
10	17.0	3024.1	1391.1	19.8
11	16.8	2613.6	1240.5	17.7
12	18.6	3459.0	1703.7	24.3
Average	**18.0**	**3198.3**	**1368.3**	**19.5**
		THREE IRRIGATIONS Not sub-soiled		
13	20.0	4216.7	2098.5	29.9
14	19.1	4122.1	2093.7	29.9
15	18.1	4663.5	1418.2	20.2
16	21.1	5530.5	2540.2	36.3
Average	**19.6**	**4633.2**	**2037.6**	**29.1**
		Sub-soiled		
21	18.3	2695.7	988.6	14.1
22	21.5	2568.0	1303.0	18.6
23	22.8	4953.7	2285.8	32.6
24	22.7	5460.3	2058.1	29.4
Average	**21.3**	**3919.0**	**1658.9**	**23.7**
		FOUR IRRIGATIONS		
17	24.1	5955.6	2362.7	33.7
18	22.1	5411.5	1877.1	26.8
19	21.8	3898.3	1811.4	25.8
20	18.1	3428.5	1847.6	26.4
Average	**21.5**	**4673.5**	**1974.7**	**28.2**

Table 4 contains similar date to that of table 3, but for the year 1902.

Table 4—Relation of Number of Irrigations to Moisture Content and Yield for 1902

ONE IRRIGATION

Plat No.	Average Moisture Content in 0-24 in. per cent.	Yield		
		Fodder	Grain	
		Lbs. per acre	Lbs. per acre	Bushels per acre
1	20.8	1119.7	209.9	3.0
2	20.2	1683.5	242.4	3.4
25	22.6	1797.4	495.0	7.0
26	22.8	2512.6	631.8	9.0
Average	**21.6**	**1778.3**	**394.8**	**5.6**
TWO IRRIGATIONS				
9	23.4	2646.0	291.8	4.1
10	21.3	3145.0	534.2	7.6
11	20.0	2272.7	331.4	4.7
12	22.9	2911.0	813.3	11.6
Average	**21.9**	**2743.7**	**492.7**	**7.0**
THREE IRRIGATIONS No Winter Irrigation				
5	26.3	5180.7	1917.6	27.4
6	23.7	4266.6	1800.0	25.7
7	23.7	5201.0	839.0	12.0
8	23.8	5033.0	820.5	11.7
Average	**24.4**	**4920.3**	**1344.3**	**19.2**
Winter Irrigated Not Sub-soiled				
13	24.8	3448.2	1665.0	23.8
14	24.1	3773.0	1445.0	20.6
15	24.1	4756.3	1131.0	16.1
16	26.6	4951.6	1238.0	17.7
Average	**24.9**	**4232.3**	**1369.7**	**19.5**
Winter Irrigated Sub-soiled				
21	26.3	3131.8	1268.5	18.1
22	27.1	3416.7	1115.3	15.9
23	28.3	5115.7	1209.5	17.2
24	30.7	4846.5	1222.2	17.4
Average	**28.1**	**4127.7**	**1203.9**	**17.1**
SIX IRRIGATIONS				
17	31.6	5385.4	1906.0	27.2
18	29.9	5050.7	2175.8	31.0
19	28.4	4745.7	2245.7	32.0
20	28.1	4209.5	2033.3	29.0
Average..	**29.5**	**4847.8**	**2090.2**	**29.8**

RELATION OF CULTIVATION TO MOISTURE AND YIELD

Table 5 shows the average per cent. of moisture in the first two feet of soil on the various dates of 1901 and the yields, with the plats arranged according to the number of cultivations.

Table 5—Relation of Cultivation to Moisture and Yield 1901—Average Per Cent. of Moisture in First Two Feet of Soil

CULTIVATED ONCE A WEEK

Date	Plat 12	Plat 13	Plat 20	Plat 21	Average
June 29	13.6	16.1	16.7	18.5	16.2
July 16	15.6	22.6	20.4	18.8	19.3
August 5	25.7	23.4	19.9	23.5	23.1
August 17	20.1	19.8	19.2	16.3	18.8
September 2	18.3	18.1	14.4	14.6	16.3
Average for the season	**18.6**	**20.0**	**18.1**	**18.3**	**18.7**
Yield Fodder	3459.0	4216.7	3428.5	2695.7	3450.0
Grain	1703.7	2098.5	1847.6	988.6	1660.0

CULTIVATED ONCE IN TWO WEEKS

Date	Plat 11	Plat 14	Plat 19	Plat 22	Average
June 29	14.8	14.4	22.2	19.0	17.6
July 16	13.2	21.6	21.5	22.0	19.6
August 5	21.6	23.1	28.5	27.2	25.1
August 17	18.1	18.7	19.2	23.1	19.8
September 2	16.2	17.8	17.8	16.4	17.1
Average for the season	**16.8**	**19.1**	**21.8**	**21.5**	**19.8**
Yield Fodder	2613.6	4122.1	3898.3	2568.0	3300.0
Grain	1240.5	2093.7	1811.4	1303.0	1612.0

CULTIVATED ONCE IN FOUR WEEKS

Date	Plat 10	Plat 15	Plat 18	Plat 23	Average
June 29	12.9	12.4	23.3	18.3	16.7
July 16	14.8	21.4	22.4	27.0	21.4
August 5	25.0	25.1	26.6	27.5	26.0
August 17	17.4	17.5	21.5	22.7	19.8
September 2	14.9	14.2	16.6	18.4	16.0
Average for the season	**17.0**	**18.1**	**22.1**	**22.8**	**20.0**
Yield Fodder	3024.1	4663.5	5411.5	4953.7	4513.0
Grain	1391.1	1418.2	1877.1	2285.8	1743.0

CULTIVATED AT DISCRETION

Date	Plat 6	Plat 16	Plat 17	Plat 24	Average
June 29	17.9	17.9	26.1	19.7	20.4
July 16	16.0	26.1	25.2	26.4	23.4
August 5	26.9	23.6	24.3	26.5	25.3
August 17	20.6	20.4	23.6	20.1	21.2
September 2	16.8	17.4	21.1	20.8	19.0
Average for the season	**19.6**	**21.1**	**24.1**	**22.7**	**21.8**
Yield Fodder	3696.5	5530.5	5955.6	5460.3	5160.0
Yield Grain	1138.1	2540.2	2362.7	2058.1	2025 0

Each plat in a series received treatment different from any other plat in the same series, either in regard to number of irrigations or sub-soiling. The average amount of moisture in the different plats of a series shows, therefore, considerable variation.

The series of plats cultivated once a week, contained an average for the season of 18.7 per cent. of moisture, and yielded at the rate of 3450 lbs. of fodder and 1660 lbs. of corn in the ear per acre. Those cultivated once in two weeks averaged 19.8 per cent of moisture, 3300 lbs, of fodder and 1612 lbs of corn; a gain in moisture 1.1 per cent over the plats cultivated once a week and a loss of 150 lbs of fodder and 48 lbs. of corn. The gain in moisture is mainly in plats 19 and 22, while the difference in yield is distributed between the two series.

The plats cultivated once in four weeks average practically the same in moisture as those cultivated once in two weeks, but show a gain of about 1500lbs. in fodder and 130 lbs. of corn over them.

The plats cultivated at discretion were cultivated oftener than once in two weeks. They show 21.8 per cent. of moisture, a gain of 1.8 per cent. and a gain of about 650 lbs. of fodder and 280 lbs. of corn over the third series.

Table 6 contains data covering the same points as contained in table 5, but for the season of 1902.

Table 6—Relation of Cultivation to Moisture and Yield 1902—Average Per Cent. of Moisture in First Two Feet of Soil

CULTIVATED ONCE A WEEK

Date	Plat 5	Plat 12	Plat 13	Plat 20	Plat 21	Plat 25d	Plat 26d	Average
April 14........	18.2	23.3	23.2	23.0	24.8	24.2	19.8	22.3
May 1.........	32.1	25.6	27.7	26.2	26.2	28.6	24.6	27.3
May 14........	34.1	23.6	24.7	28.2	28.4	25.1	27.8	24.4
May 28........	22.8	20.6	22.4	25.6	21.8	21.0	19.9	22.0
June 12........	14.4	17.8	14.8	25.8	16.3	19.9	19.0	18.3
June 30........	22.5	16.0	22.1	20.6	22.1	13.3	15.2	18.8
July 14........	21.1	18.9	21.9	32.2	24.7	15.7	14.7	21.3
July 31........	31.9	17.7	29.8	31.3	31.3	14.4	18.3	25.3
Aug. 15........	37.0	36.9	35.8	40.2	36.2	30.1	35.3	35.8
Sept. 1.........	28.6	28.4	25.8	28.3	31.6	26.9	29.4	28.4
Average for the season...	**26.3**	**22.9**	**24.8**	**28.1**	**26.3**	**21.7**	**22.4**	**24.3**
Yield Fodder	5180.7	2911.0	3448.2	4209.5	3131.8	....	....	3776.2 lbs.
Grain..	1917.6	813.3	1665.0	2033.3	1268.5	....	....	1539.5 lbs.

CULTIVATED ONCE IN TWO WEEKS

Date	Plat 6	Plat 11	Plat 14	Plat 19	Plat 22	Plat 25c	Plat 26c	Average
April 14.......	16.4	21.1	24.2	24.3	25.8	23.3	18.7	21.9
May 1.........	27.8	24.0	26.9	28.3	27.8	28.8	26.0	27.1
May 14.........	24.8	23.6	24.9	26.8	26.8	23.3	24.2	24.9
May 28.........	20.4	17.6	20.5	26.2	25.3	19.7	19.6	21.3
June 12.........	15.4	16.6	16.7	28.4	19.1	17.2	15.3	18.4
June 30.........	21.3	12.3	22.7	20.6	24.2	14.3	13.2	18 4
July 14.........	19.8	13.4	16.6	33.9	19.5	14.7	14.2	18.9
July 31.........	29.1	14.2	28.6	30.7	35.2	15.6	15.7	24.1
Aug. 15.........	36.8	31.6	32.6	35.0	36.8	30.2	33.3	33.7
Sept. 1.........	25.5	25.3	26.7	29.7	30.3	30.0	33.2	28.7
Average for the season..	**23.7**	**20.0**	**24.1**	**28.4**	**27.1**	**27.1**	**21.3**	**23.7**
Yield Fodder	4266.6	2272.7	3773.0	4745.7	3416.7	....	....	3695.0
Grain	1800.0	331.4	1445.0	2245.7	1115.3	....	....	1387.5

CULTIVATED ONCE IN FOUR WEEKS

Date	Plat 7	Plat 10	Plat 15	Plat 18	Plat 23	Plat 25b	Plat 26b	Average
April 14.......	16.7	20.6	22.8	24.5	28.5	24.4	22.1	22.8
May 1.........	26.5	25.5	28.4	30.6	27.3	29.5	23.8	27.4
May 14.........	27.4	27.6	26.1	27.8	27.6	24.9	24.1	26.5
May 28.........	22.2	20.7	22.0	28.4	27.0	21.0	22.4	23.4
June 12.........	18.9	18.3	13.7	28.0	18.1	15.7	19.1	18.8
June 30.........	22.9	10.0	21.8	22.7	26.8	12.2	14.7	18.7
July 14.........	14.6	13.4	18.6	35.5	22.2	14.9	17.9	19.6
July 31........	29.5	14.6	31.4	30.8	31.9	14.6	16.6	24.2
Aug. 15.........	34.5	35.2	33.2	38.7	39.7	31.8	36.5	35.6
Sept. 1.........	24.4	27.0	22.7	31.8	33.7	29.4	32.4	28.8
Average for the season..	**23.7**	**21.3**	**24.1**	**29.9**	**28.3**	**21.8**	**23.0**	**24.8**
Yield Fodder	5201.0	3145.0	4756.3	5050.7	5115.7	....	....	4653.7
Grain	839.0	534.2	1131.0	2175.8	1209.5	....	....	1178.0

Table 6—Relation of Cultivation to Moisture and Yield 1902—Continued
Average Per Cent. of Moisture in First Two Feet of Soil

NOT CULTIVATED

Date		Plat 8	Plat 9	Plat 16	Plat 17	Plat 24	Plat 25a	Plat 26a	Average
April 14		17.4	24.6	24.1	26.2	29.6	26.3	23.9	24.6
May 1		25.9	28.5	30.0	31.9	31.9	31.2	27.9	29.5
May 14		23.1	26.2	29.1	30.9	29.8	28.8	20.8	26.9
May 28		18.3	21.9	24.3	28.8	25.0	20.7	23.0	23.1
June 12		18.9	16.7	20.5	29.6	23.8	19.2	20.2	21.2
June 30		26.0	17.1	24.7	24.7	29.0	20.1	16.7	22.6
July 14		18.6	17.2	19.7	34.7	26.8	20.8	19.8	22.5
July 31		30.0	17.8	28.1	34.7	36.4	17.3	20.7	26.4
Aug. 15		33.8	36.7	36.1	38.9	39.6	35.6	37.4	36.9
Sept. 1		26.4	27.5	29.2	35.6	35.6	28.3	35.8	31.2
Average for the season		**23.8**	**23.4**	**26.6**	**31.6**	**30.7**	**24.8**	**24.6**	**26.4**
Yield	Fodder	5033.0	2646.0	4951.6	5385.4	4846.5	....	....	4572.5
	Grain	820.5	291.8	1238.0	1906.0	1222.2	....	....	1095.7

While the strips numbered 25 and 26 were not divided by borders into four plats, and the yield of the whole strip was weighed together, for this season they were sampled in four places corresponding with the adjacent plats and each section was cultivated with the series of plats to which it belonged. The moisture results of each section are therefore given in table 6.

The series cultivated once a week contained an average of 24.3 per cent. of moisture and yielded at the rate of 3776.2 lbs. of fodder and 1539.5 lbs. of corn.

The plats cultivated once in two weeks show a loss of .6 per cent. of moisture, 81 lbs. of fodder and 152 lbs. of corn, below those cultivated once a week.

The plats cultivated once in four weeks show a gain of .4 per cent. of moisture, 877.5 lbs. of fodder and a loss of 361 lbs. of grain when compared with those cultivated once a week. Those not cultivated show a gain of 2.1 per cent. of moisture, nearly 800 lbs. of fodder and a loss of 443 lbs. of grain compared with those cultivated once a week.

From the results of two years we conclude, that more data and many repetitions of the experiment will be required to settle the question, but that the data already obtained from four years trials indicate that on our heavy soils where cultivation is a difficult and expensive operation, weekly cultivations will not repay the time and labor expended. It is hard to decide on the best number of cultivations from the data in hand, but it is probably safe to say that a corn crop growing upon such soils should receive from two to four cultivations during the growing season.

EFFECT OF SUB-SOILING

In 1901 the four sub-soiled plats (21-24) received three irrigations and contained an average for the season of 21.3 as against 19.6 per cent. of moisture in the six plats similarly irrigated but not sub-soiled. (See table 3)

The sub-soiled plats yielded at the rate of 3919 lbs. of fodder and 1658 lbs. of corn per acre, while those not sub-soiled gave 4633.2 lbs. of fodder and 2037.6 lbs. of corn. These results show a gain of 1.7 per cent. of moisture and a loss of 714.2 lbs. of fodder and 379.6 lbs. of corn by sub-soiling.

The results for 1902 (See table 4) show a gain of 3.2 per cent. of moisture, a loss of 104.6 lbs. of fodder, and a loss of 165.8 lbs. of grain. Here again we find no relation between the percentage of moisture and the yield, and fail to find any marked advantage from sub-soiling as is the case with results in the two previous years.

RELATION OF SOIL MOISTURE TO CURLING AND WILTING OF CORN

This subject has been partially discussed in connection with "crop condition, moisture and yield."

On June 29, 1901, all of the plats were showing lack of moisture by wilting; in some cases it was only the younger corn, of the replanting. In these plats we find that the average per cent. of moisture in the first six inches was 14.7, in the second six inches 19.9, in the second foot 18.0 and the average in the first two feet was 17.5. Considering those in which the older corn was in fairly good condition but the younger corn was wilting appreciably, we find an average of 20.9 per cent. of moisture in the first six inches, 24.4 in the second six inches, and 20.9 in the second foot with a total average of 22.0 per cent.

On July 6th the plats which had not been irrigated were still suffering from drought.

Taking the average moisture content of those plats on July 16th when they were suffering fully as much as on the 6th, we find an average of 13.4 per cent. in the first six inches, 17.0 in the second six inches and 15.7 in the second foot, with an average of 15.4 in the first two feet. They had lost about 2 per cent. of moisture in spite of the .8 inch of rain.

Those irrigated on July 2nd and which were in good condition, had an average of 22.9 per cent. of moisture in the first two feet.

Plat 10 which had an average of 14.8 per cent. was wilting more than plat 9 with 16.0 per cent. on July 6th.

The only plats that showed curling during 1902 were plats 5 to 8 which were curling badly on June 20th. On June 12th they contained an average of 12.1 per cent. in the first six inches, 17.9 in the second six inches, 20.7 in the second foot and an average of 16.9 in the first two feet.

From these results we conclude that this soil, light clay loam to heavy loam, must contain about 20 per cent. of moisture in order to supply the corn plant throughout its growing period with water enough to keep it in a thrifty condition. When the moisture falls only a few per cent. below this, the plants usually begin to wilt a greater amount of water can be supplied with advantage, but if enough is applied to fill the soil and thereby shut out the air, the plants show it by turning yellow.

Young plants may show the need of water with an average of 22 per cent. in the first two feet, if the soil around their roots contains 20 per cent. or less.

These results are practically identical with those obtained in the moisture work during 1900 and published in Bulletin 38 of this station.

EFFECT OF WINTER IRRIGATION

Plats 13 to 16 received winter irrigation while plats 5 to 8 received no winter irrigation and both series received three irrigations during the growing season.

The winter irrigated plats contained an average of 24.9 per cent. of moisture in the first two feet, yielded at the rate of 4232.3 lbs (2.1 tons) of fodder and 1369.7 lbs. (19.5 bushels) of corn in the ear, while those receiving no winter irrigation contained 24.4 per cent. of moisture and yielded at the rate of 4920.3 lbs (2.5 tons) of fodder and 1344.3 lbs. (19.2 bushels) of corn in the ear. See table 4.

On April 14th, the winter irrigated plats contained an average of 23.6 per cent. of moisture in the first two feet, while those not winter irrigated contained 17.2 per cent., a difference of 6.4 per cent. By June 12th, eight days before irrigation, both series contained nearly the same amount, 16.4 per cent. in the winter irrigated and 16.9 in the others, so that difference in moisture content does not explain why the winter irrigated were in better condition, unless the presence of more moisture early in the season made the plants more vigorious.

The benefits derived from winter irrigation will depend very much on the nature of the soil. Where the soil consists of clay loam and clay to a depth of several feet, water will penetrate it very slowly and it is possible to wet it by frequent winter irrigations when it would be impossible to do so during the growing season without detriment to the crop. In soils such as occur on these plats, the water penetrates quite readily and winter irrigation seems to be unnecessary if one or two heavy spring irrigations are given.

LATERAL PERCOLATION

Electrodes were placed in the east and west sections of the strips 25 and 26, in 1901, one set at 3 to 6 inches and another at 15 to 18 inches below the surface. The sets placed at the edge of the borders showed no appreciable rise in the moisture content of the soil during the season, and we therefore conclude that there was no appreciable percolation to a distance of three feet from where the water was applied.

BULLETIN NO. 47

JUNE 1903

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

A Six-year-old group of Arborvitæs, N. Mex. Expt. Station.

SHADE TREES AND OTHER ORNAMENTALS

By Fabián García

SANTA FE, N. M.
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The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others as far as the editions printed will allow.

*Resigned, April 1, 1903.

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SHADE TREES AND OTHER ORNAMENTALS

By Fabián García.

INTRODUCTION

The planting of shade trees and shrubs in New Mexico in the towns and country is done only on a very small scale. One cannot help but be impressed with the scarcity of shade trees either along drives and roads, or in the home grounds. Planting shade trees should be done more extensively throughout the Territory. More interest should be taken in this important subject. While a shade tree, growing beside a drive or in the home grounds, is not generally a source of income to the individual or comunity, if it is properly placed and trained, it may be a thing of beauty and comfort. I am sure that all of us appreciate the beautiful and enjoy comfort. Think of how much a collection or a group of trees, when properly placed, adds to the general surrounding of a place. Why have there been so few trees generally planted throughout the Territory? There must be a reason for this state of affairs, and the following answer may be applicable to this question.

The early settlers cared little for such ornaments. The later wave of immigration from the East was largely composed of settlers transitory in their habits. This was a population largely of persons who were seeking fortunes, with little or no intention of remaining here permanently, and their efforts were turned in a different direction than that of home making. Aside from these causes it has been somewhat difficult in the past to get trees, except the cottonwood, for planting. The scarcity of water for irrigating trees has also had more or less to do in preventing the planting of shade trees.

The lack of information regarding shade trees as well as shrubs and evergreens has been constantly realized, and as a contribution to our knowledge on the subject, the following list of trees, shrubs, etc. is given. The greater number of these has been tried at the Experiment Station, and a few of them can be found growing in the vicinity. Most of them are well adapted to our climate, but there are some that have not been successfully grown. Nearly all have been introduced from other states.

HINTS ABOUT PLANTING AND CARE OF TREES

While the planting of a tree is a simple operation and most people have an idea as to how to do it, yet it seems advisable to point out a few of the more important things to keep in mind in the planting and training of the young tree.

Soil. Success with shade trees depends in a measure on the soil. If the land is too sandy or gravelly, so as to be deficient in plant food or be subjected to droughts, it is important to make a large sized hole and put in a load of good loam. On the other hand, if the soil is too heavy an adobe, it is also advisable to dig a large hole and break through the adobe soil or in some way loosen it, and put in the bottom of the hole good loam and mix with this the adobe soil. In any event have a soft foundation for the roots to penetrate. If the land is not too sandy or too adobe, the hole need not be so large but always make it of sufficient size to take in all the roots of the tree without crowding them. The size of the hole depends on the kind of soil and on the size of the tree. If the soil is in proper condition and the tree is four to six feet tall with a normal amount of roots, a hole twenty inches in every direction should be large enough.

Planting the Tree. Having dug the hole properly, care should be taken in setting the tree to have the roots spread out as naturally as possible. Do not have the roots all in a bunch. Use a fine soil, at least, next to the roots. It is well to pack the soil firmly, especially if the soil is dry and the tree is not likely to be irrigated just as soon as it is planted. Before setting the tree in the hole, all broken and dead roots should be removed. Plant the tree about one or two inches deeper than it grew in the nursery. This is done for the reason that after the trees have been irrigated the soil tends to settle.

Irrigation. Water is probably the most important factor in the success of growing trees. Most of the failures in starting shade trees seem to be due to the insufficient amount of water the trees get. Immediately after the tree is planted it should be thoroughly watered or irrigated, especially if the soil is dry. In about twelve to fifteen days the trees should be irrigated again and in about a week thereafter, or as soon as the soil begins to dry, it is well to go over the trees and pack the soil around them, which tends to crack open. The subsequent irrigations should be frequent, at least, till the tree becomes well established. This is especially important in the case of the Cottonwood and other poplars.

Time to Transplant. The planting of trees should always be while they are dormant, or just as they are beginning to grow in the spring. In other words, shade trees can be transplanted any time during the winter but in this climate the months of February and March are preferable.

Size of Trees to Plant. Most people like to plant large trees, i. e. trees five or seven years old: trees that have made ten to twelve feet or more of growth. Such trees can be successfully planted if care is taken to dig them with a good supply of roots. However, a two or three years old tree is preferable. The shock of transplanting is less severe on small trees than it is on large ones.

Heeling-In. This is simply the temporary covering of the roots of the tree to keep them from drying after they are dug, until they are planted permanently. Trees that are bought away and shipped in, usually have to be heeled in for a few days. Some care is necessary in the heeling of trees. Since the trees are usually heeled in at an angle there is some danger of air spaces being left between the trees and the lower wall of the trench. If air spaces are left, the roots are liable to dry up before the trees are set out.

Digging. In digging up trees care should be taken to take up a large amount of roots in order to support the tree. It may be given as a rule that the more the roots, the better the condition for the tree to grow. Do not allow the roots to be exposed to the dry air too long; protect them as soon as possible after digging the trees.

A Few General Points in Pruning. While pruning is necessary to secure the effect desired, it should be avoided as much as possible. If young trees are pruned from the time they are set out, there will be little or no need of removing large limbs later in the life of the tree. The growth of buds that may develop into undesirable branches can be checked by pinching them off.

Trees are pruned to give them forms that are desirable for some particular purpose. Trees for lawns or windbreaks may be better when they have a low trunk and branches quite low down. On the other hand, shade trees should have a high crown or head and a bare trunk, six to eight feet is a good height.

Dried or dead limbs can be removed at any time in the year. The pruning of large branches during the growing season is not to be recommended as such an operation reduces the leaf surface, and this is likely to check the growth of the tree to some extent. As a rule the best time to prune is in the late winter just before the growth starts. At this time the pruning, especially of large branches, is most safely done. Frequently the pruning of trees is done without having any reason for it. Do not cut limbs unless a definite object is to be accomplished.

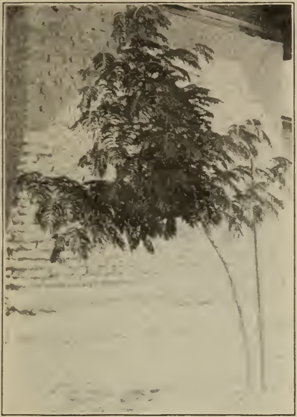

Fig. 1. Improperly started young Honey Locust tree, N. M. Expt. Station.

A most common mistake made in pruning young trees is the removal of all the branches along the stem to the head. The pruning of all of these branches along the trunk of the young trees induces them to make too much growth at the top for the amount made by the trunk, and thus a top heavy tree may result (see fig. 1) which is more liable to be broken by the wind. To avoid this unevenness of growth in young shade trees, one should only remove a part of the lower branches and shorten back the remaining ones which can be entirely removed later. By allowing a few shortened branches to grow along the trunk of the young trees during the summer (see fig. 2), the plant food is more evenly distributed along the trunk and top of the tree, i. e., the trunk grows as well as the top, without materially in-

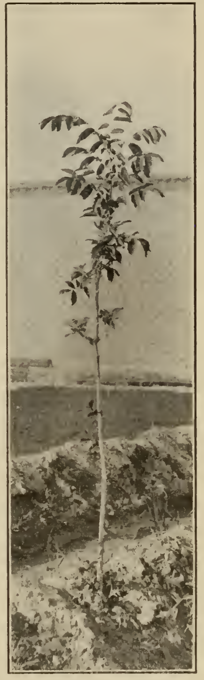

Fig. 2. Properly started, N. M. Expt. Station.

creasing the size of these side branches which can be removed later without injury to the tree. The pruning of young trees the first few years of their growth should be with the object in view of increasing the size of the trunk as well as the size of the top. If the trunk is entirely destitute of any branches the tree is liable to grow too much to top.

Where limbs rub together one of them should be taken off. The head of street trees, especially, should start about six or more feet high. It is quite noticeable in this locality that the Russian Mulberry, which is planted somewhat extensively as a shade tree, and which tends to branch low down, has been trained too low. This method of pruning is not desirable for street trees. Every kind of tree has its own natural form and habits of growth. In pruning different kinds of trees it is not well to try to make all of them the same shape or form. It is a good idea to study the natural tendency of growth of each kind of tree and encourage the natural form. For example, the Box Elder has a more or less spreading, somewhat roundish head and it would not be desirable to prune it to make it grow tall and narrow, while on the other hand, the Carolina Poplar is tall and narrow and it would be somewhat difficult to prune it to make it spread.

Cutting Back Young Trees. It is a common practice to cut back the small trees when they are set out. This operation induces them to branch out. The height at which to cut back the young trees depends on the size of the tree and also on the object for which the tree is being grown.

Topping Old Trees. This practice can only be recommended when it is judiciously done and the operator has some definite object in view to be accomplished by the operation. There is no doubt that the injudicious topping of old trees is frequently the cause of many of them dying. In this locality, the common method of topping old trees is to cut all the branches right down to the main stem of the tree, leaving the trunk with many large scars exposed to the action of our dry spring winds. These scars remain exposed to the wind and sun until the new growth begins to shade the top. Sometimes the scars will crack quite deeply into the wood and occasionally the tree dies.

If topping is to be done, it is believed that a less severe treatment will produce more satisfactory results. The practice in this locality of topping trees which are in a vigorous condition is not necessary and should not be done. Topping, however, is helpful for old trees when the crown limbs are dying or show signs of unhealthy growth. When the root system has been reduced (as sometimes big roots have to be removed) topping is beneficial as it balances the activities of the tree.

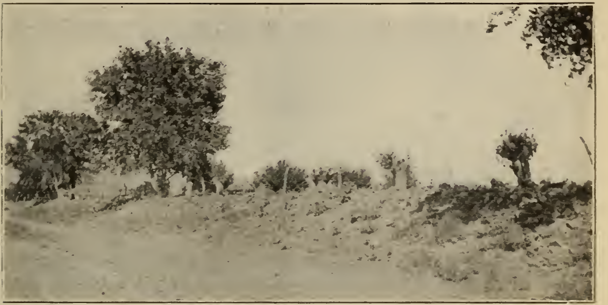

Fig. 3. Showing how severely shade trees are frequently topped in this locality. The two trees to the left were not topped.

TREES.

Ailanthus (*Ailanthus glandulosa*, Desf.),

This tree commonly known as the "Tree of Heaven," is a fairly rapid growing tree. It does well in our climate and seems to grow well on any kind of soil. It is quite common along the streets of Las Cruces. For street planting it is recommended to plant the pistilate or female trees, as the male tree is said to exhale a disagreeable odor. It is propagated from seed.

Almond (*Prunus Amygdalus*, Baill)

The almond grows as well as the peach tree. In the case of the seedling bitter almond good shade trees may be had, but as a rule the almond is short lived.

Apricots (*Prunus Armeniaca*, Linn.)

It may seem strange in this case to see the apricot classed with the shade trees. The native or seedling apricots are hardy and grow in any kind of soil, and by training them high, they make very desirable shade trees for yards, especially. Plant the seed where the trees are to grow.

Ash (*Fraxinus spp.*)

It is believed that many of the *Fraxinus* will grow here; they are, however, slow growers. There is a native species *Fraxinus velutina*, Torr. that grows to be thirty or more feet high, and very hardy, but it is a slow grower.

Fraxinus lancolata, Borkh. This green ash grows well, but it too, is a slow grower. It is doing very well in the Station plantation. A good way is to get small trees from a nursery and plant them out.

Box Elder (*Acer Negundo*, Linn.)

This is a large sized tree, of rapid growth, with a roundish head, and producing a dense shade. This tree is well adapted for planting here, since it is hardy and easily propagated. It is one of the earliest to leaf out in the spring and one of the first to shed its leaves in the fall.

California Pepper Tree. *(Schinus molle,* Linn.*)*

This is a semi-tropical evergreen tree, with a rounded outline and pendulous branches. In California it seems to be one of the most extensively cultivated ornamental trees. This tree is not grown in New Mexico and from present indications, it seems to be too tender for our winters. In the summer of 1901 seeds of the Pepper Tree were planted in an old discarded cold frame.

The seedlings that came up made a growth of five to seven inches during the season. The small seedlings which were partially protected with a thin canvas, stood the winter quite well; only a few of them being winter killed.

In the spring of 1902 these small trees started out very vigorously, and some of them made a growth of seven feet in height and one inch in diameter at the base, during the season. The vigorous succulent growth did not mature thoroughly before fall. During the winter of 1902-3, some of the largest Pepper Trees were covered all over with a wagon cover, and the rest were left uncovered. About the first of April, 1903 the trees were examined: it was found that all but two had been entirely winter killed. By the first of June the two trees that were only killed back to the ground had made a growth of about five inches. It is doubtful if the Pepper Tree will prove hardy enough to withstand our winters.

Catalpa (*Catalpa speciosa*, Warder)

This tree has large showy foliage and flowers and is a rapid grower. It usually grows vigorously during the first few years when it begins to decline. In the Mesilla Valley it has been shown to be of no value. A few years ago the Catalpa was planted quite extensively in this locality, and while the trees grew fairly well at first, most of them are now dead. The tree seems to be a poor drouth resister. It is possible that in other sections of the territory where a permanent and continuous supply of water can be had for irrigation, the Catalpa may grow well. It is well, however, especially if large numbers of trees are to be planted, to experiment first with a few specimens to see if the Catalpa is adapted to the particular section.

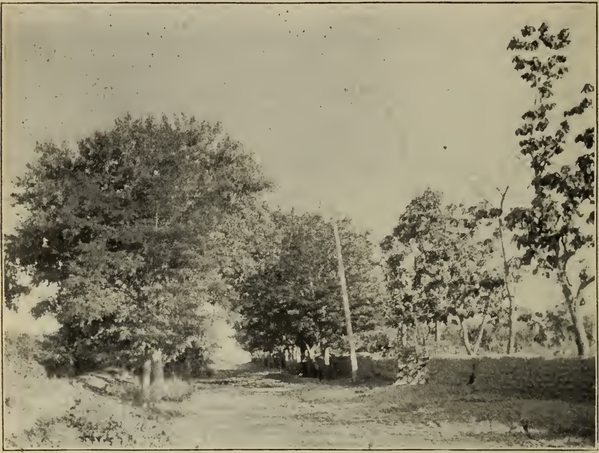

Fig. 4. Avenue of Cotton Woods, Honey Locust, and Catalpa in Las Cruces. The Catalpas (to the right) are dying.

At the Experiment Station it has been observed lately that some of the trees have a sort of a root-gall.

China Berry Tree *(Melia Azedarach*, Linn)

This is a vigorous and large growing tree. Many specimens can be found in this locality that are over thirty feet in height. It resists drought well, has a roundish spreading head and casts a dense shade. Its abundant cymes of flowers are very fragrant in the spring.

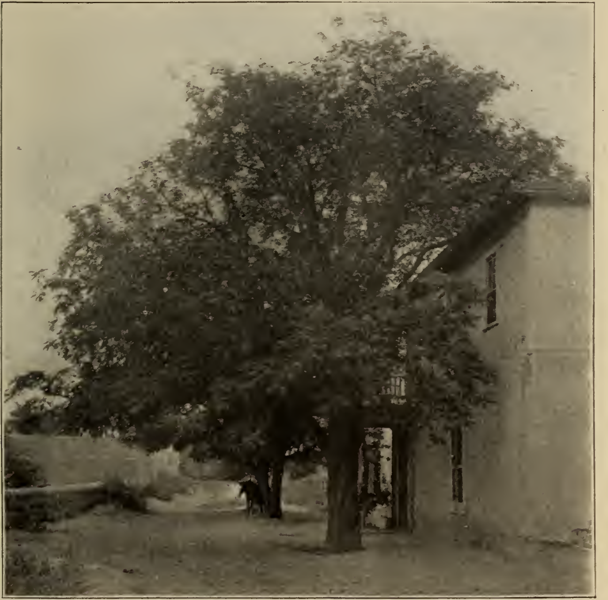

Fig. 5. Very old China Berry Trees in front of Casad's place in Mesilla. They are great drought resisting trees.

The one bad feature of this tree is the large crop of berries which drop off during the winter and spring. On the whole, the China Berry Tree is a good shade tree. It is propagated from seeds which are somewhat slow to germinate.

Var. *umbraculiformis*, Hort. This is the Texas Umbrella Tree. It is a striking tree, and in leaf, bloom, and fruit resembles the China Berry Tree. It has a low roundish umbrella-shaped head with a dense foliage. This tree is medium in size, hardy and withstands drouth well. It has been quite extensively planted in this section. While the Umbrella Tree is attractive, it has the undesirable feature of splitting easily by the winds. This is a serious fault, and one that cannot be overcome easily. Usually the tree begins to split when three or four years old. Due to this bad feature, its popularity is liable to decrease. It is propagated from seed.

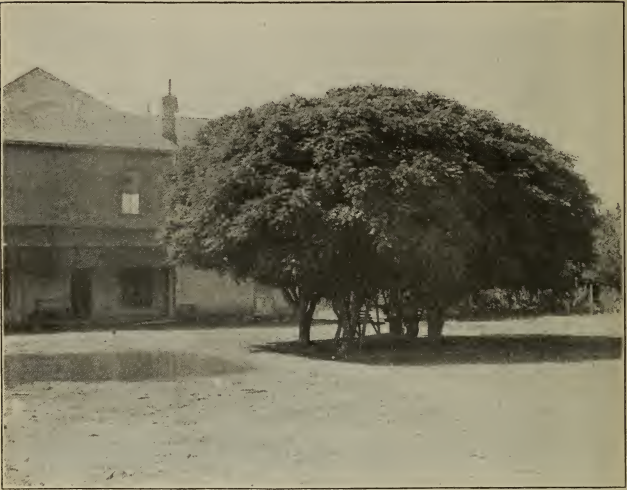

Fig. 6. Texas Umbrella Trees at the Woodland place in Mesilla.

Cotton-Wood (*Populus Fremontii Wislizeni*, Wats.)

This is the tree that is most extensively planted in New Mexico. It is native in our valleys, and many places have dense "bosques" or forests of it. It grows large and rapidly. There are trees in this locality that measure 10½ feet in circumference. It is a good tree for planting, except that many times it is difficult to get started, as it requires a great deal of water, and this is frequently not at our command. Many times people are disappointed in this tree. These trees start vigorously the same spring they are planted; and the second or third year, especially, if a limited supply of water is applied, a large per cent. of them are likely to die. If the Cotton-wood can be well established it makes a good sized tree. In planting this tree, plant the staminate or male trees, if possible, as the pistilate trees are *very* objectionable on account of the cotton of the seed pods. The trees are easily propagated from seed or cuttings. If the soil is moist and the water is not too deep beneath the surface, the Cotton-wood is very easily started from cuttings. The writer was much interested this spring, while at Carlsbad and Roswell, in the easy and satisfactory way people have of starting the Cotton-wood there. The common way adopted at these places, is to take good sized limbs and soak them for a while and then plant them out.

Elder (*Sambucus Mexicana,* Presl.)

The Elder, while not a large tree, can be trained to become a fairly respectable one. It is desirable, however, for planting in single specimens or in groups. This introduced species grows to the height of fifteen feet, and makes a very compact and roundish head, casting a dense shade. It sheds its leaves late in the fall and leafs out very early in the spring. It grows somewhat slowly and thrives in almost any soil and stands drouth well. The Elder has usually a peculiar crooked and knotted trunk. It can be propagated by cuttings or

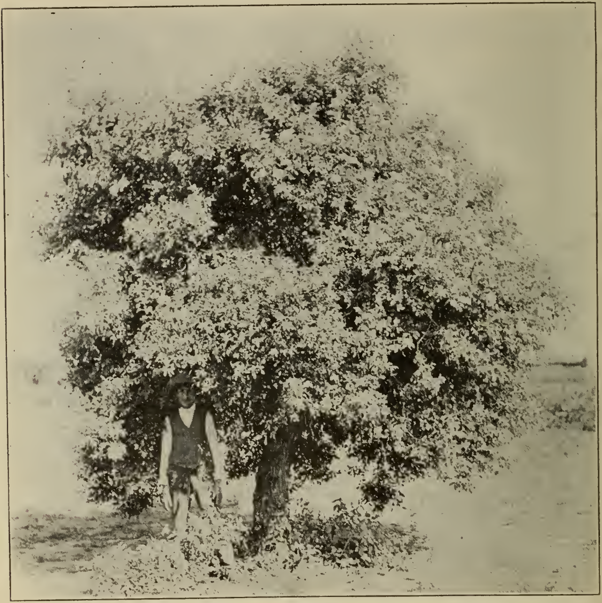

Fig. 7. Elder Tree, an excellent low growing tree in this Valley.

sprouts. It has been more or less of a favorite among the Mexicans of this locality. In many of the Mexican yards large specimens of it can be found growing.

Elm (*Ulmus Americana,* Linn.)

The Elm is a desirable tree for planting. This species has done well in the Station plantation. The American Elm is a medium fast growing tree. It does not require the amount of water to establish it as does the cotton-wood. It grows tall with long thin leaders, becoming more or less top-heavy the first few years of its growth, especially if it grows vigorously. The Elm is usually long lived and is propagated from seed, but the average person can do better if he buys his trees from some nursery.

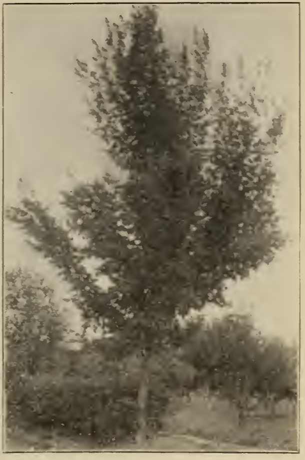
Fig. 8. Elm tree at the N. M. Expt. Station.

Eucalypts (*Eucalyptus spp.*)

Much has been said about growing the Eucalyptus tree in New Mexico. In order to ascertain if the Eucalyptus could be grown, at least in the warmer valleys of the territory, the Experiment Station obtained in February 1902 from thə Richman and Mills nursery, Fullerton, California, a number of seedlings of the *Eucalyptus rostrata*, *E. corynocalyx*, *E. rubosta*, and *E. globulus*. All of these seedlings were kept in the green house till later in the season. On May 22, 1902, *E. corynocalyx* and *rostrata* were set out in the field. The other two species were not set out, as they were about all dead.

The Eucapypts planted out made a good growth during the season. Specimens of the *E rostrata* grew three feet in height. In the fall a few of the trees were covered with straw and dirt to protect them from the cold. The winter was not severe. Besides the winter being somewhat mild, it rained considerably. In the spring of 1903 the Eucalypts were examined and it was found that all the unprotected trees had been winter killed to the ground, and some had been killed entirely. The ones that had been protected during the winter were killed back to about two to three inches of the surface. A new and vigorous growth had started from the stumps of these trees. At this time, June 10th, the *E. rostrata* has made a growth of twelve inches.

With the limited amount of data on this subject, nothing definite can be said in regard to the adaptability of the hardier species of the Eucalyptus in southern New Mexico. More kinds have been set out this spring. The species now planted in the plantation are *E. rostrata*, *E. corynocalyx*, *E. rudis*, and *E. polyanthema.* These are some of the species recommended by Prof. Alfred J. McClathie, as being more likely to grow in the valleys of Southern New Mexico.

Flowering Willow (*Chilopsis linearis*, Sweet.)

Two varieties, the purple and white, have been introduced. They grow to be medium sized trees and somewhat thin foliaged. The purple is the quicker and larger growing variety. These willows are grown principally for their flowers.

Kentucky Coffee Tree (*Gymnocladus Canadensis*, Lam.)

This is a good tree that is growing quite well in the plantation and promises to be a good one for this climate. The tree has a more or less rough and scaly bark and large compound leaves, with large and long stem. The leaves have the appearance of small branches and in the fall, when they drop, the trunks of the small trees have very noticeable scars on the bark, which indicate where the large leaf stems were attached- This tree can be propagated by seed. Trees that were started from seed three years ago on the station farm are now five feet tall.

Locust, Black (*Robinia pseudacacia*, Linn.)

Next to the cotton wood, this is the tree generally planted by the average New Mexican. It is one of the best trees for southern and central New Mexico, as it withstands drouth remarkably well, grows rapidly with an upright form, and is attractive in flower in the spring. To give an idea as to how fast this tree grows in this climate, the following figures have been taken from trees now growing in the Station forestry plantation. The plantation has a number of different kinds of trees planted in the spring of 1899 from yearling seedlings. And with the exception of being cultivated for two seasons they have been allowed to grow naturally, i. e., they have not been pruned or relieved of any suckers. The height of the highest trees in this plantation, now (Dec. 1902) is twnenty-two feet and they measure in circumference eighteen inches. This tree sprouts badly when the roots are injured by plowing. The Black Locust is probably among the best general pur-

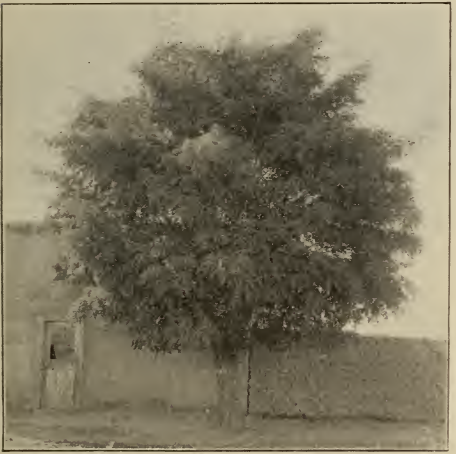

Fig. 9. Black Locust growing in the streets of Mesilla. One of our best trees.

pose shade trees and the most popular in the Mesilla Valley.

Locust, Honey (*Gleditschia triacanthos*, Linn.)

This tree is well adadpted to our conditions, being hardy and able to withstand drought well. But owing to the fact that it grows so slowly it is not so desirable for general planting as the Black Locust. Good ornamental hedges can be made of this tree. Both of the locusts can be easily propagated by seed but the seed is somewhat slow in germinating.

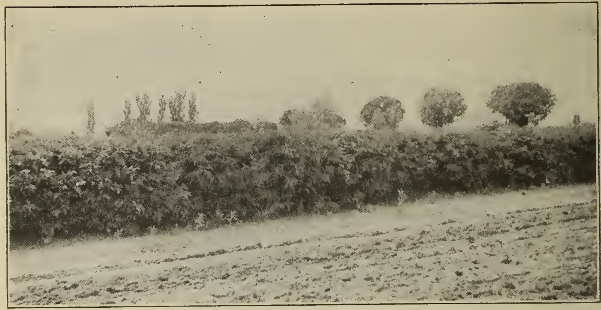

Fig. 10. Honey Locust hedge at the N. Mex. Expt. Station.

Mulberry, Russian (*Morus alba Tatarica*, Loudon.)

This is a most valuable tree for this section and ranks along with the best trees tried. It is very hardy, withstanding drought remarkably well. It is almost as rapid a grower as the Black Locust, makes a more attractive and roundish head when properly trimmed, and gives a more dense shade. In order for it to make a good tall shade tree, it needs to be trained high, since, if allowed to grow naturally, it will make too low a head. The first few years of its growth it tends to sprout considerably all along the stem. The main objectionable feature for planting it along walks or in front yards, is the fruit. This obstacle can be easily overcome, however, by planting staminate trees which may be propagated from cuttings of male trees. The fruit is of no commercial value, as it is very insipid. Birds are very fond of the fruit, and a windbreak of the bearing trees around orchards would serve a double purpose. The bearing variety can also be planted to advantage where the fruit can be eaten by chickens. The Mulberry makes good screens or windbreaks, and it should be more used for this purpose than it is. The trees can be propagated by seeds, cuttings, layers or grafting. On the whole, it is one of the best and most desirable trees for this region. The leaves are well adapted for feeding silk worms.

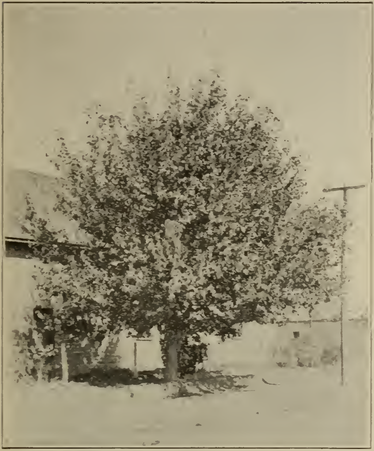

Fig. 11. A well shaped Russian Mulberry but started too low down, N. Mex. Expt. Station.

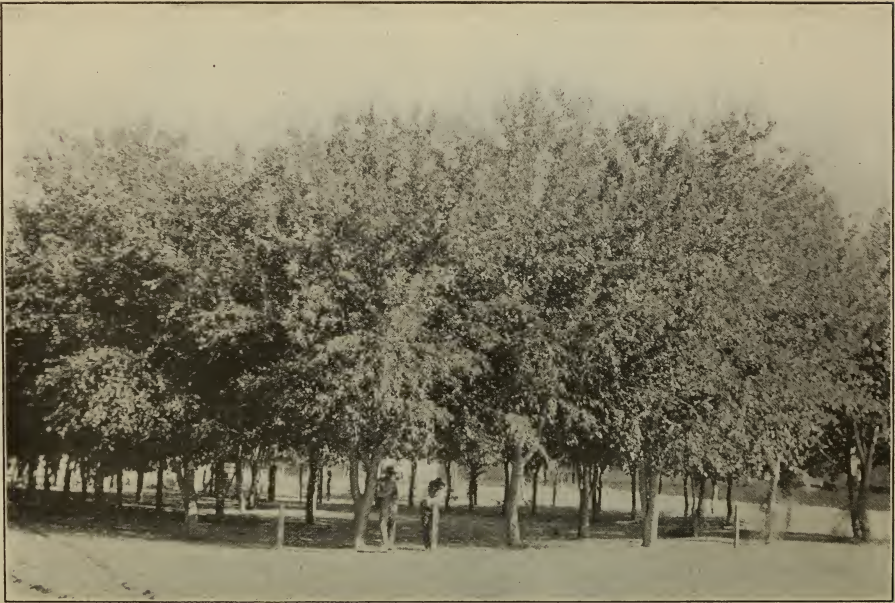

Fig 12. Russian Mulberries in the Plaza of Mesilla. These trees have not been irrigated for about ten years.

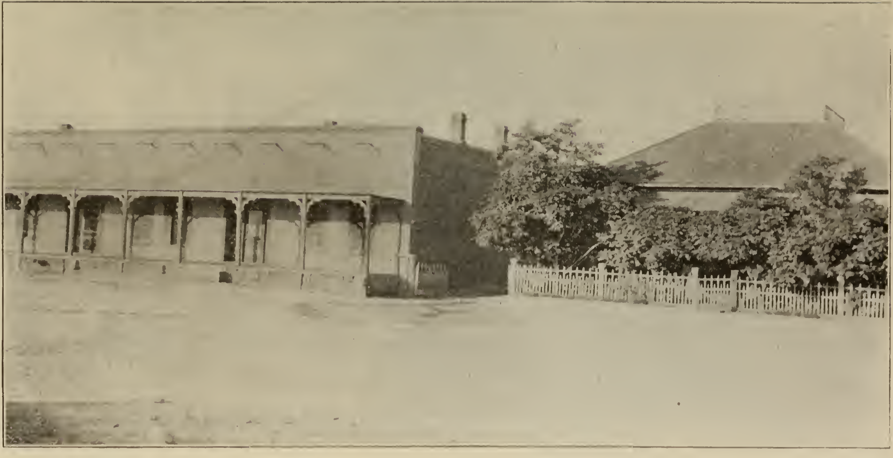

Figure 13. Above irrigation level in Las Cruces, Trees improve the appearance of a place. These trees are watered from a well by means of a hose.

Osage Orange (*Toxylon pomiferum*, Linn) (*Maclura aurantiaca*, Nutt.)

The most popular use for this plant is for hedges, as it makes a hedge which, if properly trimmed, is stock proof in a short time. Many hedges of the Osage Orange have been planted in this locality with satisfactory results as regards its defensive nature. However, it is not a desirable hedge for small places, since it is such a voracious feeder that it soon depletes the soil of much of its fertility for some feet away, so that nothing but grass and weeds will grow. The Osage, while it is not a very desirable plant to have around on account of being so thorny and hard on the soil, should be adopted to some extent as shade trees, especially where it is difficult to start the less hardy kinds. Its moderately large, glossy, green dense foliage is very attractive and in this respect excels the Locust. As a shade tree it is giving good results in this locality. For planting along the drives where there is a likelihood of stock skinning the trees, the Osage can be planted to advantage.

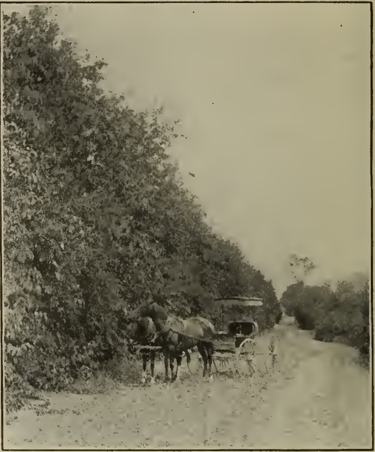

Fig. 14. An old hedge of Osage Orange at Mesilla.

Pear (*Pyrus communis*, Linn.)

Like the apricot the native or seedling pears make good shade trees. They are hardy, attractive and longed lived. These are propagated from seed. Many of these seedling pear trees can be found growing in some of the Mexican home grounds where they attain a height of twenty-five feet or more.

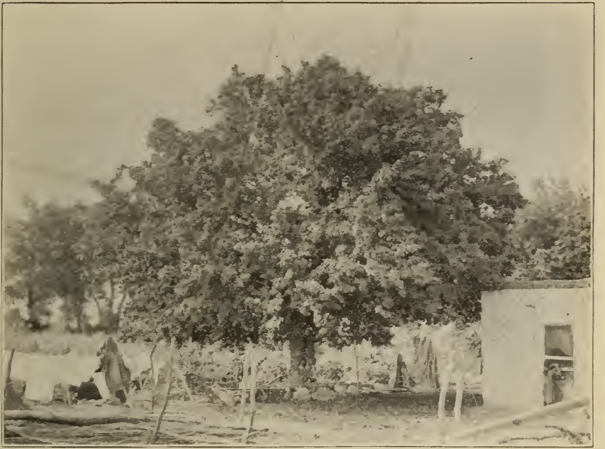

Fig. 15. Native pear used as a shade tree in a Mexican country home near Las Cruces.

Poplars (*Populus spp.*)

Both the Lombardy and Carolina can be grown here: they grow very fast and for quick results they are desirable, but of course they are not good trees for shade as they grow too narrow and tall. They require abundance of moisture to grow well and generally speaking, they are short lived. They can be grown to advantage as a nurse tree with the slower and longer lived kinds. They are very easily propagated from cuttings.

The Carolina is somewhat pyramidal and casts more shade than the Lombardy, which is very narrow and formal. In this connection, Prof. Bailey has the following to say of the Lomabardy, and in a measure it may be applicable to the Carolina as well: "For shade it has little merit, and for timber none. People like it because it is striking and this, in an artistic sense, is its gravest fault." "The Lombardy should rarely, if ever, be seen as a single specimen; and above all its formality and stiffness should not be emphasized by planting it in rows along country roads."

Populus alba, Linn., which is commonly known as the Silver or White poplar, is a tree more or less pyramidal in growth and has a whitish bark and the leaves are wooly on the under surface. It seems to be short lived. Trees of this kind at the Station have not given satisfaction. However, a few of them growing in a yard near the Station on a loose sandy soil, are doing well.

Purple Leaf Plum (*Prunus Pissardi*, Hort.)

This tree does well here, and while it does not grow large enough to be planted as a shade tree, it is a very desirable small ornamental tree. The wood and leaves are dark purple, and so is the fruit from the time it sets until it ripens.

Salt Cedar (*Tamarix Amurensis*, Hort.)

This shrub or tree is perfectly hardy and withstands drouth remarkably well. After it has been started, it often grows without irrigation. It is a rapid grower, and its bluish green cedar-like foliage gives it a graceful appearance. This "cedar" is well adapted and can be used for hedges. It is a difficult matter to get it to grow as a tree, but it can be done by presistent trimming. The branches bend down as though they were top heavy. In Albuquerque, N. M., there are many hedges and some trees of the Tamarix. This plant seems to be especially adapted for planting in places where only a small amount of water can be had. It will take care of itself, provided it has been given a good start. It is easily propagated from cuttings.

Nig. 16. Screen of Salt Cedar in a back yard at Mesilla Park growing with very little water.

Soft Maple (*Acer saccharinum*, Linn.)

The soft maple has given poor results in the Station plantation. The new growth which is quite tender and succulent gets killed back during the winter. In East Las Vegas the Soft Maple is also giving poor satisfaction. It appears that the trees begin first to turn white or light color in the leaves and as this progresses the limbs begin to die at the end and finally the entire branch is dead. In this way all the limbs gradually die and often the body of the tree-cracks open.

Sycamore (*Platanus occidentalis*, Linn.)

While this is a large and vigorously growing tree in many places where it grows well, so far the results with it at the Station have not been very satisfactory. Two attempts have been made to grow the Sycamore. The first trees planted grew two seasons, making only a small growth, and then died. The second lot is growing slowly.

Walnuts (*Juglans spp.*)

The trees of some of the small hard shelled black walnuts do admirably in this climate. They seem to be very hardy, withstanding more dry weather than most other trees, growing moderately fast and making good shade trees. They can be propagated by planting the nuts. Two kinds of these walnuts are growing in the Station orchard.

The English Soft Shell walnut has not given satisfactory results. It seems that the new growth does not ripen enough before the winter comes and most of it is killed back. A tree that the writer knew of in the Casad orchard a few years ago never bore, and did not grow over eight or ten feet, though it was over ten years of age; most of the new growth of this tree was killed back every year.

The pecans, however, are hardy and do very well here, but they grow slowly. Very large trees which bear profusely are now growing in this vicinity. The trees are propagated from seed. The nuts should be placed where the trees are to grow, as it is a difficult thing to transplant successfully a pecan tree on account of its long tap root and the lack of secondary roots.

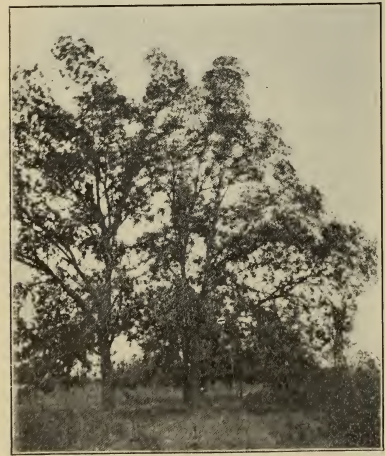

Fig. 17. Pecan Trees in bearing at Mesilla.

Wild Olive or Russian Oleaster (*Elaeagnus angustifolia, Linn.*)

This is a Russian tree, and grows to be of medium size. While it is moderately slow in growth, it has given satisfactory results at the station. It is hardy and withstands drought well. It grows with a rounded head, and has narrow leaves which are silvery white underneath. The blooms which appear in May are yellowish and have a pleasing fragrance; but to some people the fragrance is sickening. In some sections of the West and in Russia, the Wild Olive is used as a hedge plant. It is propagated by means of seeds. Prof. N. E. Hansen says: *"This form is generally known as the Russian Wild Olive, although Russian Oleaster would be a more exact name. It is allied to the Buffalo berry and does not belong to the olive family."

Willows. (*Salix spp.*)

While the willows grow well and sometimes attain large size, they are not desirable as shade trees.

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*South Dakota Sta. Bull. No. 72.

EVERGREENS

A few years ago, the idea prevailed in this region that evergreens would not grow here. It has been demostrated at the Station that many kinds do admirably and it is believed that a much large number of kinds will grow successfully. The following is a list of those evergreens tried at the Station.

Arborvitaes (*Thuja occidentalis*, Linn.)

There are many varieties of Arborvitaes and most of them are excellent for small places, either in groups or as single specimens and also for hedges. A few of these varieties were planted at the Station the spring of 1896, and some of them are now ten feet high. The *Pyramidalis*, which is pyramidal in form, is compact and the most rapid growing and largest of the varieties tested. The *Elegantissimo* is a less compact variety and lighter in color, becoming quite yellowish along the edges of the leaves during the earlier part of the summer. The variety commonly known as the "Golden" is one of the most elegant and popular. It is medium in growth and somewhat pyramidal and very compact in form. The beautiful golden tint

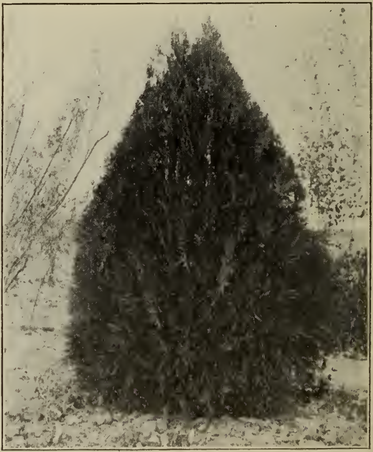


Fig. 18. A seven year old "Golden" Arborvitae, which measures 12 feet high and 7 feet through at base, N. Mex. Expt. Station.

that the foliage assumes during the summer makes this variety very attractive and desirable. A Chinese variety is very compact and almost spherical in form and somewhat dwarf in habit of growth.

The Arborvitae can be propagated by both seeds and cuttings. The cutting method is slow and somewhat uncertain, as the cuttings are hard to root. The seed method is easiest and best, but the seedlings are likely to vary. They will grow well on a soil that is quite poor and require very little cultivation. All the treatment given to the Arborvitaes growing on the Station grounds has been to keep the weeds down and the ground moist. Irrigating them is the main feature to keep in mind. They will stand a great deal of water in our soil. Frequent irrigations should be given, especially during the spring and early summer, at the time when they are growing more rapidly.

In planting coniferous evergreens small specimens, about twelve to eighteen inches high, should be secured. This sized trees are preferable to the larger ones because they are easier to transplant and a much larger per cent. will grow. It is a difficult matter to get the large specimens to grow, especially when these have been shipped a long distance. Many people do not like to plant the small trees because it takes them so long to grow to an appreciable size, so they send away for trees three or more feet in height, only to be disappointed in most cases by their dying. In transplanting coniferous evergreens much greater care than with deciduous trees is required. They should be transplanted with as much earth on the roots as possible, so as to keep the small roots from drying out during the operation. The most important feature in the operation is not to allow the roots to become dry; the sap in the roots thickens and will not resume its natural state, and the result is that the tree is likely to die. The best time to transplant these trees seems to be in the spring just about the time the growth is starting. After the small evergreens are transplanted, they must be irrigated and it is a good plan, though not necessary, to partially shade them with boards from the southern sun.

Box Tree (*Buxus spp.*)

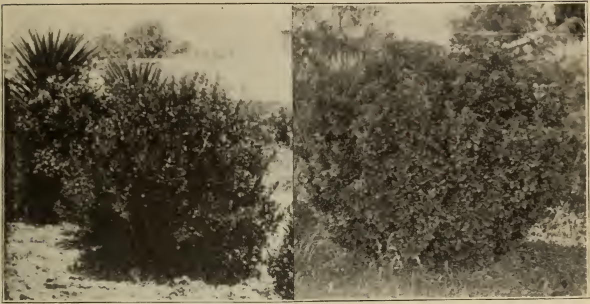
Varities of this evergreen are doing well here. The Box Tree thrives in our climate and soil. It is a small and quite ornamental bush and it grows very slowly. It is extensively planted for hedges and edging in other states. Seedling trees planted at the Station in 1896 are now 2 1-2 feet high. They can be propagated by cuttings or division, but the former method is more preferable.

Burning Bush or Spindle Tree (*Euonymus spp.*)

The *Euonymus* is a very interesting and desirable evergreen shrub. It thrives well in this climate, is a much larger and more rapid grower than the *Buxus* and the color of the foliage changes but very little in the winter. It is very desirable for planting either in groups or as single specimens, and for ornamental hedges it would make a valuable plant. While the growth is compact and the lower branches are well developed there is a tendency to send out straight leaders which have to be cut back in order to keep its outline regular. The three kinds at this Station are growing well.

The *Euonymus Japonicus*, Linn. is the most rapid grower of the the three (see fig. 20) and has a roundish outline, with green foilage.

The *Euonymus Japonicus medio-pictus*, Hort. is also a rapid and compact grower, with yellow branches and leaves blotched yellow in the center. This is a very ornamental shrub, and a hedge of it would be most attractive, see fig. 19.



Figs. 19. Fig. 20,
Burning Bush or Euonymus showing compact growth, very desirable evergreens for ornamental hedges, N. Mex. Expt. Station.

Euonymus Japonicus argenteo variegatus, Rgh. is a medium and moderately loose, upright grower with silvery variegated leaves. It is not as large as either of the other varieties. The *Euonymus* is easily propagated from cuttings and the treatment of the small plants out in the garden is the same as for the Arborvitae.

Himalaya Cedar (*Cedrus deodora, Loudon*)

This tree is commonly known as the Himalaya Cedar from the fact that it grows naturally on the Himalaya mountains, where it reaches a height of 150 feet and is of a pyramidal form. The silvery green foliage with the semi-weeping habit of the branches makes it a very graceful and beautiful tree. It is doing admirably at this Station; it grows more rapidly than the other evergreens, and its color changes but very little during the winter. A seedling tree transplanted in the spring of 1898 has grown from a small twelve inch seedling to a tree that is about ten feet in height. This is a most promising evergreen for this section.

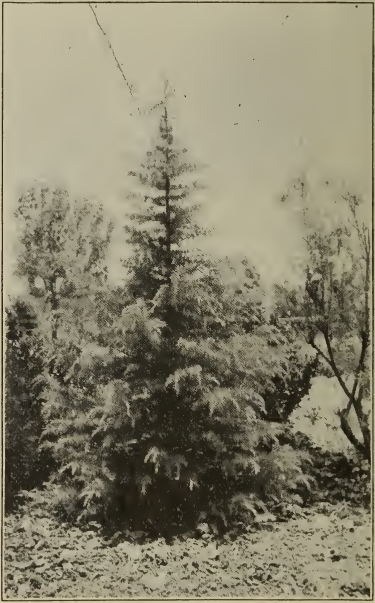


Fig. 21. A Himalaya Cedar (True Cedar) growing at the Expt. Station.

The *Cedrus Atlantica* has given very unsatisfactory results. The directions given for the Arborvitae in regard to the propagation, cultivation, etc., are applicable to the *Cedrus*. Trees of this genus are true Cedars, while the trees usually called Cedars are really Junipers.

Japanese Arborvitae or Japanese Cypress (*Retinispora plumosa*, Beissn. & Hochst.)

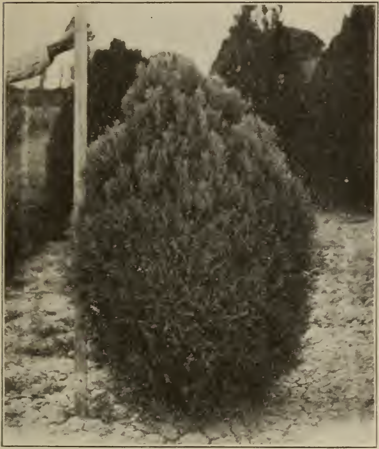


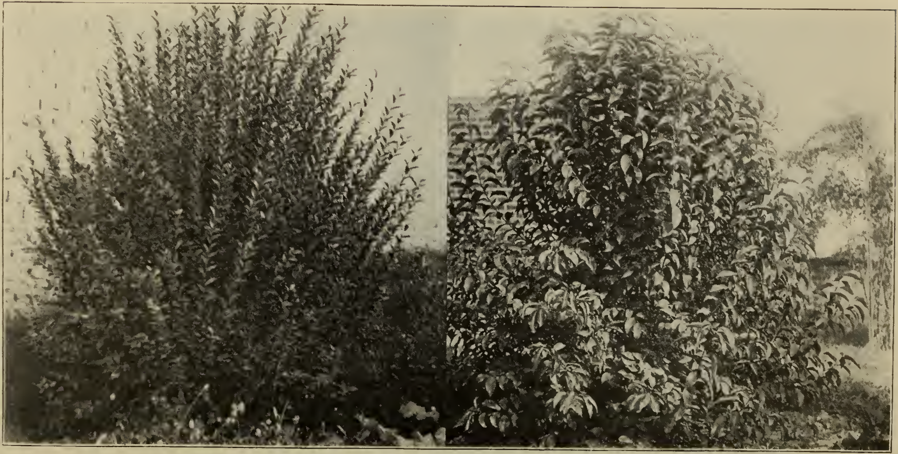
Fig. 22. Japanese arborvitae, a very attractive little evergreen, N. Mex., Expt. Station.

This is a dwarf, compact and somewhat spherical little tree, and with its silvery green foliage in the summer and its purplish tint in the winter, it is very ornamental. It is perfectly hardy here. An idea can be had of its dwarf habits of growth by saying that the specimens planted in the ornamental grounds in 1896 have made a growth of three feet in diameter and four and one-half feet in height.

Privets (*Ligustrum spp.*)

Ligustrum ovalifolium, Hassk. which is commonly known as California Privet is upright and slightly pyramidal in habit, with medium sized (2 to 3 inches) somewhat elliptical, dark green leaves. The leaves are thickly set on the stem, making the internodes short; during the winter the green foliage turns to a purplish hue which is very attractive. This shrub is perfectly hardy and may reach ten or more feet in height. It can be propagated by cuttings. The California Privet is well adapted and used extensively for hedges in the states where it grows well. It is also very ornamental when planted in groups or as single specimens. This shrub should be more generally planted in southern New Mexico.

Ligustrum Japonicum, Thunb. or Japan Privet grows



Figs. 23. California

Fig. 24. Japan

Two species of Privets, showing arrangement and size of leaves, N. Mex. Expt. Station.

about the same as the preceeding species, but with more spreading branches. It has glossy, green leathery, and larger leaves, about three to four inches long. The leaves are not so thickly set as in the California Privet. The tip ends of the leaves may be injured by our frosts during the winter. It is also a good hedge plant and is well adapted for planting for ornamental purposes, but in this locality it is not considered so desirable as the other species. Both of these Ligustrums may drop their leaves during some of our more severe winters, especially if the plants are not kept well irrigated. They can be propagated from cuttings.

Red Cedar or Red Juniper (*Juniperus Virginiana*, Linn.)

The Red Cedar may grow to be one hundred or more feet high in other states. It has quite a dense pyramidal head and well developed branches right from the ground. This tree produces a berry-like fruit which is purplish in color and covered by a thick whitish bloom.

The trees on the Station grounds which were planted in 1898 are growing very vigorously, showing that the Red Cedar is well adapted to this climate. It is a handsome and a very desirable tree for planting, and one that should be more generally used in ornamental grounds. It can be propagated by cuttings, but the more common way is by planting the seeds.

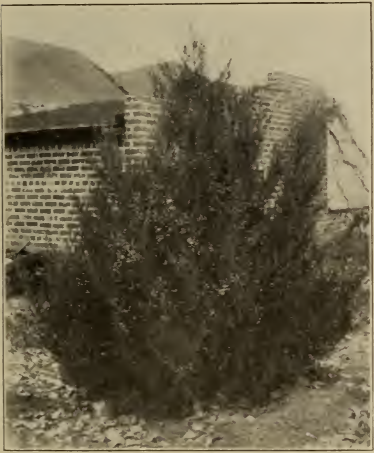


Fig. 25. Red Cedar (true Juniper) at the Expt. Station, showing well developed lower branches.

SHRUBS.

Althea (*Althaea spp.*)

This shrub which is commonly known as the Rose of Sharon, is hardy and grows from four to six feet high. It blooms very freely during the summer. The flowers are usually produced on the current year's growth, and the more vigorous the growth the better it blooms. The shrubs are usually cut back or trimmed in the early spring. The Althea requires a great deal of water to do well. It can be propagated from cuttings.

Artemesia (*Artemesia Abrotanum*, Linn.)

This is a native of Europe and Russia and is a medium sized growing shrub. It has been used as a hedge plant in Canada. It begins to grow early in the spring and with its feathery foliage it is quite attractive in the early part of the summer. After the blooms dry up it assumes a dull green color. The branches are killed back every winter. It is easily propagated from cuttings. On the whole it is not a desirable shrub to plant here.

Barberry (*Berberis Spp.*)

Species of the barberry seem to succeed in this climate. These are low and ornamdntal shrubs, many of which are spiny.

Berberis vulgaris, Linn. as well as the purple leaved variety have done well at the Station.

Bird of Paradise (*Caesalpinia Gilliesii*, Wall.)

This shrub is well adapted to this climate. (See N. M. Station Bulletin No. 40.)

Bladder Sena (*Colutea media*, Willd.)

This is a vigorous and hardy deciduous shrub. In two years it has made a growth of five feet and is somewhat spreading in habit. Its orange or reddish yellow pea-like blossoms are very abundant in the early spring, and the shrubs continue blooming, but in a less degree, during the season. The inflated and many-seeded pods are quite decorative. The *Colutea* may be propagated either by seeds or hard wood cuttings.

Crape Myrtle (*Lagerstroemia Indico*, Linn.)

This is a beautiful little shrub. It blooms freely during the summer, and the fringed flowers make it the more attractive. It grows in this climate, as a rule, as high as three feet. While it is a desirable shrub for planting, it is somewhat tender and unless protected during the winter, the branches are likely to be winter killed down to the ground, but in the spring new and vigorous shoots will sprout, which will bloom abundantly in the summer. There are a number of varieties in cultivation. but only a few have been tried at the Station, the red flowering kind giving the best results. The Crape Myrtle can be propagated by cuttings of the ripe wood.

Fuchsia (*Fuchsia Spp.*)

These small shrubs can be grown for summer use in the garden, but they are too tender to stand our winters. They are better adapted for house culture where they can be kept all the year around. Fuchsias can be propagated from seeds and cuttings of half matured wood.

Japan Quince (*Cydonia Japonica*, Pers. *Pyrus Japonica*, Thunbg.)

This is a small shrub with spreading and somewhat spiny branches, glossy leaves, and attractive, scarlet quince-like blooms. It is perfectly hardy and is well adapted for borders, shrubbery, and low hedges. It is propagated from seeds and cuttings.

Lantana (*Lantana Camara*, Linn.)

This plant does well during the summer. It is a dwarf and spreading bush. Its free blooming habit and its large number of cymes of flowers add to its desirability for planting in the garden. The most serious drawback to the Lantana in this climate is that it is not hardy enough to stand our winters. This necessitates planting new plants every spring. The old plants can be taken up in the fall and put away indoors during the winter and in the spring they can be planted out again. It is readily propagated by soft wood cuttings.

Lemon Verbena (*Lippia citriodora,* Kunth.)

This is a popular shrub in many places for planting in the garden as it has very fragrant foliage, sprays of which can be used in mixed bouquets. It does well here. The branches which sprout from the crown make a growth of about four feet in height. This new growth is, as a rule, partially or wholly winter killed, but will start again very vigorously in the spring. A good way to propagate the Lemon Verbena is by division, i. e. by cutting a piece of the root away with a crown bud or eye.

Lilac (*Syringa vulgaris.* Linn.)

There are a number of varieties of the Syringa Vulgaris in cultivation. It is a popular and ornamental flowering shrub. The purple and white are the two varieties generally planted. Both are early bloomers, and the fragrant panicles of blooms mixed in and towering above the glossy foliage, makes the lilac a very desirable shrub for spring. The white variety is slightly earlier than the purple and sometimes the blooms and buds develop too early and are killed by our late spring frosts. On the whole the purple variety is the more satisfactory of the two. The bushes of these varieties are usually compact and grow from four to six feet in height. The lilac can be propagated from seeds, green and hard wood cuttings and also by division and grafting. It produces its blooms on the previous year's wood and so care should be taken in pruning it. It should be pruned soon after blooming. If pruned at any other time many of the flower buds will be destroyed.

Oleander (*Nerium Oleander.* Linn.)

While the Oleander is a well known evergreen shrub and extensively cultivated in the warmer countries, it is not hardy enough to stand our winters. It is better adapted and largely used for house culture in large pots or tubs. It is particularly liable to the attack of the Oleander scale and mealy bug.

Plumbago (*Plumbago Capensis*, Thunb.)

This is more or less of a climbing, straggling, semi-upright shrub. The blue and white are two varieties used at the Station and both of these grow well in the summer and bloom profusely, but like the Lantana, they are easily killed. The old plants should be thoroughly protected or taken indoors during the winter.

Scarlet Sage (*Salvia splendens*, Ker-Gawl.)

This is a flowering shrub that is fairly well adapted to this climate. The flowers which are borne in terminal racemes are scarlet in color. The plant is of an upright habit, and the specimens growing at this Station grow two or three feet high. Frequently they are partially or wholly killed back in the winter. In the spring new and vigorous branches start from the ground. The Scarlet Sage can be propagated either by seeds or cuttings.

Siberian Pea Tree (*Caragana arborescens*, Lams.)

This makes a hardy and very ornamental plant in the spring here. It can be used as a hedge or for planting in gardens, and will grow to be a small tree. In Russia, it is said to grow about fifteen feet in height. The locust-like foliage which is of a light green and appears early in the spring, and the yellow-pea-like blooms are desirable features in this small tree. It is easily propagated from cuttings, and does not kill back in the winter.

Spireas (*Spiraea spp.*)

Many species of the spireas succeed in this climate. They are very ornamental deciduous shrubs and very desirable for planting in borders, masses, or single specimens where medium sized plants are desired.

Spiraea Van Houttei, Zabel. has succeeded on the Station farm. It is an early and heavy bloomer and is a splendid kind for planting.

Spiraea prunifolia, Sieb. & Zucc. has done fairly well. It is a most graceful shrub with slender upright branches, which bend over in the early spring when they are full of the small clusters of pure white flowers. It blooms early and appears to be slightly less hardy than the former species.

Spiraea cantoniensis, Lou. *S. Reevesiana*, Lindl. has a straggling and upright habit. The branches reach from four to six feet in height. The specimens at the Station hold the leaves well during the winter. It has not bloomed as profusely as the two former species.

Spiraea Billardii, Hort. (See Station Bulletin No. 40.)

These spireas should not be pruned very much. Thin out and remove all the weak and old branches. These plants can be propagated by seeds or hard or green wood cuttings.

VINES.

Asparagus, Ornamental (*Asparagus Sprengeri*, Regel.)

While we may grow this plant out in the open during the summer, it is altogether adapted and extensively grown for house use. It is a very popular and decorative plant. The leaves are glossy, green, narrow and flat, while the branches are long, drooping and branched. It is of easy culture, propagation is done by division or by seeds.

Asparagus plumosus, Baker, like the last named species is used for house culture and in growth, in some respects, resembles the garden asparagus, except that it is a slower grower, and its foliage is finer and the branches are flatter and spread out horizontally in delicate sprays. It is a most decorative and desirable plant for house use. The leaf sprays or strands will keep fresh for a number of days after being cut.

Chinese Wisteria (*Wisteria Chinensis*, DC.)

This is a good hardy climber. It is a rapid grower, twining around any support it may have, has a pale green foliage, and large drooping clusters of purplish pea-shaped flowers. The Wisteria is difficult to propagate from cuttings as they do not root easily. A very good way to propagate the plant is by layering.

Clematis. (*Clematis paniculata.* Thunb.)

For a detailed discussion of this species, which has been introduced, see Station Bulletin No. 40.

Honey Suckle (*Lonicera spp.*)

Species of this plant succeed in this region. The evergreen and climbing kinds are very desirable, especially as they are well adapted for covering walls and trellis work.

Lonicera Japonica, Thunb. is a vigorous climbing evergreen vine with white and yellow flowers on the same stem sometimes changing to purplish, outside. These blossoms are very fragrant. It blooms early in the spring and continues blooming most of the summer. This is a most desirable vine and very extensively planted in this locality.

Lonicera Chinensis, Wats. is closely related to the preceeding species: it is an evergreen with very similar flowers and smaller foliage, but is not quite so vigorous a grower as the japan form.

Lonicera Tatarica, Linn. belongs to the shrub honeysuckles and grows and blooms well here. Its leaves appear very early in the spring. Sometimes during the later part of the summer the edges of the leaves become brown as though they were attacked by blight.

Lonicera Tatarica virgindalis grandiflora, Hort., is also a bush honeysuckle and is proving to be just as hardy as the *Lonicera Tatarica*, but it is prettier and more showy when it is in bloom early in the spring. The flowers which are quite large, have striped and marble pink and white petals. The berries are quite large and bright red in color.

Other forms of the bush honeysuckle have just been planted in the Station arboretum, but as yet no data has been gathered as to their adaptability to this climate. The honeysuckle can be easily propagated by layers or hardwood cuttings. The cuttings of the Japan form root very easily.

Japanese Fern Ball.

This is a house plant and has been much advertised and pictured extensively in the florists' catalogues. While it succeeds in the moist sections, it is unsatisfactory in this dry climate. The balls started in the Station greenhouse have been a failure.

Hop Vine (*Humulus Lupulus*, Linn.)

The hop plant probably ranks first as a rapid grower among the climbing plants that may be used here. It makes a growth of twenty or more feet during one season and has a dense rough foliage. The hop root is perennial, but the growth is herbaceous and is winter killed to the ground; in the spring shoots grow from the crown. The hop vine is well adapted for covering walls and unsightly objects. It is propagated from seeds and from cuttings.

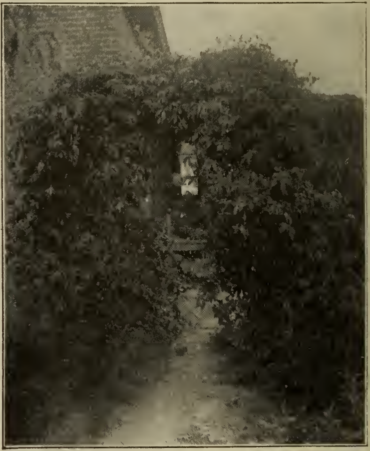


Fig. 26. One season's growth of Hop Vine at Messila Park.

Madeira Vine (*Boussingaultia baselloides*, H. B. K.)

This vine comes from perennial tuber-like roots which sprout vigorously in the spring and grow during the season, if conditions are favorable, as high as twenty or more feet. Its somewhat fleshy, light green, and medium sized leaves, and abundance of small, delicately fragrant flowers during the summer and fall, and its easy culture are features that make the Madeira Vine very desirable. The vine itself is winter killed every year down to the root. The tubers can be left out in the open till spring, and then they can be divided and planted out. This is a good way of propagating the vine.

Roses, Climbing *(Rosa spp.)*

Few forms of the climbing roses have been tried, but they grow and bloom well.

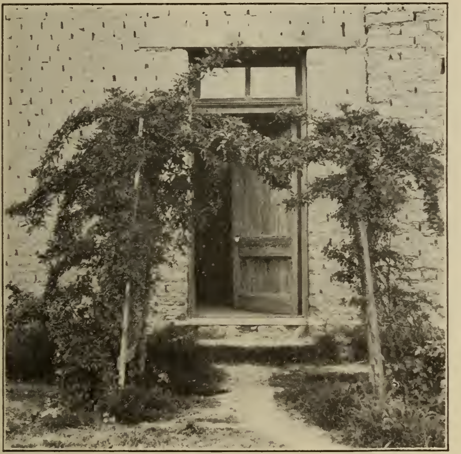


Fig. 27. Crimson Rambler set out in the spring of 1899, N. M. Expt Station.

The *Crimson Rambler* has succeeded admirably at the Station and it blooms profusely in the spring. It is a rapid grower, frequently the new sprouts make a growth of eight or ten feet in one season. The flowers are produced on semi-pyramidal panicles, each containing a large number of the blooms. The individual blooms are small, about one inch in diameter, and crimson in color. It blooms only once a year and this in the spring. It is an excellent rose for verandas and arbors and other trellises.

The White and Yellow Ramblers are very similar to the Crimson Rambler except in color, and while these have not been tested at the Station, they will probably succeed here.

Madam Plantier is a climbing rose, but not so vigorous a grower as the Crimson Rambler. The white blooms are produced in clusters and are larger than the crimson rose blooms. It is an excellent rose for trellis work.

The *Lamarque* is also a climbing rose, it grows well and blooms profusely. The blooms are white, some of them having a yellowish tint. This being of the ever-blooming group, is very desirable for planting.

Silk Vine *(Periploca Graeca*, Linn.)

The Silk Vine is a deciduous and twinging plant, and succeeds admirably in this climate; it should be extensively planted as it is of easy culture and is a rapid grower, reaching sometimes to a height of fifteen to twenty feet in one season. The blooms which are produced in clusters, are small and purple in color and of secondary importance. The foliage is the attractive feature. The leaves are long, narrow, glossy and dark green. The Silk Vine is easily propagated from layers, but more commonly from cuttings.

Trumpet Flower or Trumpet Creeper (*Bignonia Tweediana*, Linn.)

This is a climbing vine. It grows and blooms well. It has large tubular reddish orange flowers, and is an excellent vine for covering walls to which it clings without any artificial support. It can be propagated from cuttings.

Vinca or Periwinkle (*Vinca minor*, Linn.]

This is a hardy running or trailing vine. It stands drought quite well, its large glossy leaves keep green during the winter, and its large, blue, funnel-form blooms are out early in the spring. It is a good plant for borders, and for use in rock work or small mounds. It can be propagated by cuttings or division, and also by layers. The runners can be allowed to root and in the spring they can be severed from the old plant and set out.

Virginia Creeper [*Ampelopsis* (*Parthenocissus*) *quinquefolia*, Michx.]

This is perfectly hardy and is the most popular deciduous climbing plant here. It is of a rapid growth and in the fall its foliage assumes a beautiful reddish tint. The Virginia Creeper is well adapted for covering walls, verandas, porches, etc. It is easily propagated by cuttings, division or layers.

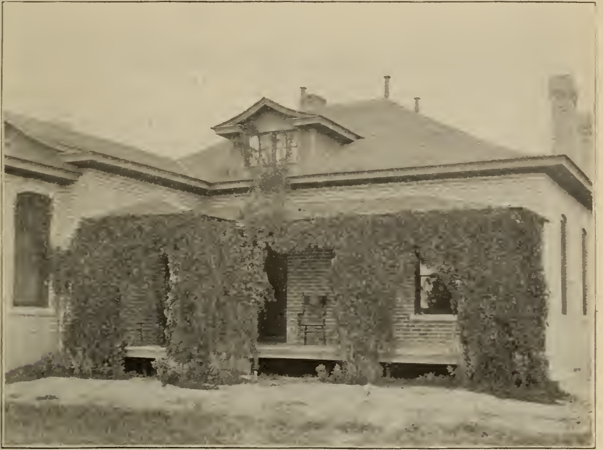


Fig. 28. A good use of the Virginia Creeper at J. E. MacGregor's home, Mesilla Park. Two years after setting out.

GRASSES.

Bamboo (*Phyllostachys Henonis*, Mitford.)

The Bamboo has done quite well at the Station. It will stand drought well, and is a slow grower. It is quite ornamental, especially in the winter as it is an evergreen. It can be propagated by dividing the clumps. The Bamboo spreads by an underground stem.

"Carrizo" (*Arundo Donax.* Linn.)

"Carrizo" is the Mexican name for the English Giant Reed, and because it is so common a name in this section, it is used here. It is a perennial grass, with large and dense green leaves. The "Carrizo" is well adapted to this region. It thrives along the acequia or ditch banks as well as on places where it gets little or no irrigation and it is a good drought resister. It grows rapidly, often the canes make a growth of twelve or more feet in one season. The "Carrizo" is useful as well as ornamental. It is occasionally used for shade in poultry yards and in front of unsightly objects in the back yard, and is well adapted for low windbreaks. In the fall the canes terminate in a large plume, something like the pampas grass. The "Carrizo" is easily propagated by dividing the clumps. The matured canes when laid in a moist place will root. There is also a small native form which may be found growing in low swampy places. Figure 29 shows a windbreak of the "Carrizo" eighteen months after planting. It has had but one irrigation. This plant is very common in this locality. A few years ago the Station obtained a clump of a variegated

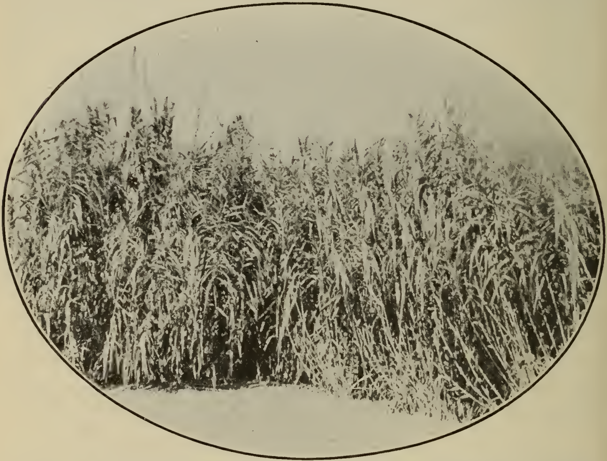


Fig. 29. A clump of "Carrizo," an ornamental as well as useful grass. Grown extensively in this locality.

form of this plant from Joseph Vestal and son of Little Rock, Ark. This variety is not as rapid nor as large a grower as the common Mexican form.

Eulalia (*Miscanthus Sinensis.* Anders. *Eulalia Japonica.* Trin.)

The variety *Zebrinus* has been very satisfactory at the Station. It is remarkably hardy and an ornamental grass and is well adapted for bedding. The leaves are banded and quite attractive. The bands are light yellow in color. It can be propagated from seed or by division.

Pampas Grass (*Cortadería argentea*, Stapf. *Gynerium argenteum*, Nees.)

This is a hardy and very ornamental tall plumy grass. The species tried has succeeded well. It responds quickly to good soil and plenty of moisture. This grass is very desirable and most effective in lawn work. It is easily propagated by division or seed. The plants grow as high as five feet.

Yucca (*Yucca aloifolia*, Linn.)

This is an introduced species and while this Yucca grows fairly well on the Station farm, the results are not altogether satisfactory. It has the undesirable habit of breaking off at the surface. The Yucca makes a growth of three to five feet and then it breaks off and will sprout badly. The sprouts will grow three to four feet and they, in turn, break off. It has also been observed that it is more or less subjected to the attack of a fungous growth which appears on the leaves. On the whole it is considered an undesirable Yucca to plant.

A LIST OF GOOD TREES, EVERGREENS, SHRUBS, VINES AND GRASSES.

TREES.

The following list of trees, while not large as compared with the number that may be adapted to this section, may be helpful in the selection of kinds:

Black Locust, Russian Mulberry, Box Elder, China Berry Tree, Elm, Ash, Honey Locust, and the common pear and apricot seedlings. Where a low headed and dense foliage tree is desired, both the common Elder and Texas Unbrella Tree may be planted. For large and quick growth, where an abundance of water for irrigation can be had or where the water is only a few feet from the surface, the Cotton Woods are good kinds to plant. The Catalpa is considered a poor tree here.

EVERGREENS.

Arborvitaes—The *Pyramidalis* and the "Golden" are the leading varieties. The Japanese form is a good dwarf kind.

Junipers—The "Red Cedar" is the only Juniper that has been tested at the Station.

Cedars—Two species have been tried, the *Cedrus deodora* and *C. Atlantica.* The former species is the best.

Euonymus—Of these shrubs the *E. Japonicus* and *E. Japonicus medio-pictus* are preferable.

Privets—Both the California and Japan forms are very good, but the former is more desirable.

SHRUBS.

Spireas—Both the *Prunifolia* and *Van Houttei* are good shrubs. The latter seems to be more hardy.

Other shrubs are Crape Myrtle, Lemon Verbena, Lilac, Bladder Sena, Bush Honey-Suckle, and Altheas. The Althea requires an abundance of water to do its best. The *Caragana grandiflora* is a good shrub.

VINES.

The Honey Suckle, Madeira Vine, Silk Vine and Virginia Creeper are among the best vines tested. The Crimson and *Lamarque* are two good running roses.

GRASSES.

The "Carrizo" is perfectly hardy and makes a large and quick growth.

Both the *Eulalia Japonica* and Pampas grasses do well and are very ornamental.

ACKNOWLEDGEMENT.

The Cyclopedia of America Horticulture by Prof. L. H. Bailey and the So. Dak. Bulletin No. 72, by Prof. N. E. Hansen have been taken as authorities on the scientific names of the trees, etc., in this bulletin, and they have been freely consulted.

The writer is much indebted to Prof. E. O. Wooton of this Station for valuable suggestions in the preparation of this bulletin, and for the use of photographs of Figs. 5, 14, 17, 22, 26, 27 and 28.

The rest of the illustrations are from photographs taken by the author.

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BULLETIN NO. 48

SEPTEMBER 1903

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

SOIL MOISTURE INVESTIGATIONS

FOR THE SEASON OF 1903

BY

J. D. TINSLEY and J. J. VERNON.

SANTA FE, N. M.:
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1904.

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The Bulletins of this Station will be mailed free to Citizens of New Mexico who are interested in the work done here, and to others as far as the editions printed will allow.

SUMMARY

1.—Too much water causes growing wheat to turn yellow, retards ripening a few days, and causes a decreased yield of grain.

2.—This (adobe) soil when kept three fourths saturated throughout the season is too wet for wheat.

3.—Wheat will do well up to the time of filling in a soil that would be comparatively dry for corn, and if the soil is kept quite moist at the time of filling the yield will be about as good as if this high moisture content had been maintained throughout the season.

4.—Adjacent plats kept in nearly identical moisture condition show considerable differences in yield, and also plats which vary very much in moisture content may give nearly the same yield. This shows that other factors exert a marked influence on yield.

5.—The most of the water applied to these plats was held in the first three feet of the soil.

6.—When this soil is fairly dry it will absorb about five acre inches of water.

INTRODUCTION

The coöperative experiments, between the Departments of Agriculture and Soils, were continued during the season of 1903. The results of previous years were reported in bulletins Nos. 31, 38, and 46 of this station.

The plats having been in corn for the two previous years it was thought advisable to change the crop and accordingly wheat was planted this year.

The principal objects in view this year were:—

1.—To learn the effects of different numbers of irrigations on the yield of wheat, especially the effect of frequent irrigations from the time of heading until the crop began to ripen.

2.—The relation between the number of irrigations, the amount of moisture in the soil and the yield.

3.—The distribution of the soil moisture in depth, percolation.

4.—The relation between the amount of water applied and the soil moisture.

The department of Agriculture had charge of the planting, irrigating, observations on growth, harvesting, threshing and weighing up the yield. The department of Soils took the samples and determined the moisture, and made the water measurements.

Mr. H. C. McLallen superintended the work for the department of Agriculture and Mr. R. H. Hart, student assistant, made the moisture determinations for the department of Soils.

PLAN OF THE EXPERIMENTS

Location.—The piece of land used in the experiments for 1901 and 1902, and which has been described in Bul. 46, was used this year. It was divided into 24 plats as in 1902 and the same spaces were left between the three tiers of plats toward the north. The arrangement and numbering of the plats is shown in the accompanying diagram.

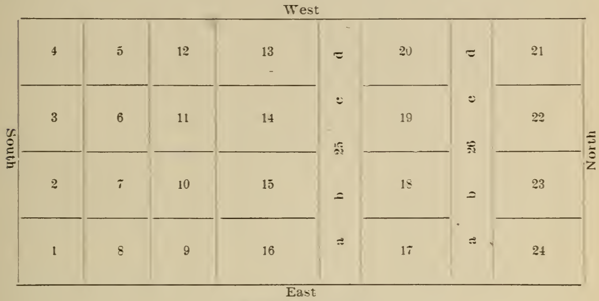

DIAGRAM OF PLATS

The areas of plats 1 to 12 were about one twentieth of an acre and those of plats 13 to 24 were about one tenth of an acre. Strip 25 was .18 acre and strip 26 was .13 acre.

Each plat was surrounded by a border high enough to hold the irrigating water applied.

Irrigation.—The following plats were to be irrigated once in three weeks until the wheat began to head, 1, 2, 3, 4, 5, 6, 11, 12, 13, and 14; after that time plat 13 was to be irrigated every third day, 1 and 12 every fourth day, 5 every fifth day, 4 and 14 every sixth day, 2 and 11 every eighth day, 6 every tenth day, and 3 every twelfth day.

When the plats were irrigated it was found that portions of plats 1 and 2 were too high to be wet by running the water on them from plats 4 and 3, and in order to irrigate them thoroughly it was necessary to run the water along the north side of tier 21 to 24 and then along side of the east tier of plats until it reached plat one, and from it on to 2. These plats were therefore omitted from the heading group and are classed with those irrigated once in three weeks.

Plats 21 and 22 were to be irrigated once a week; 23 and 24 once in two weeks; 17, 18, 19 and 20 once in three weeks—this seems to be about the number of irrigations usually given by the farmers in the Mesilla Valley; 15 and 16 once in four weeks; 9 and 10 once in five weeks; 7 and 8 once in six weeks.

These irrigations all began on April 27 as the wheat was then beginning its spring growth.

MOISTURE DETERMINATIONS

All of the samples were taken with an auger which was worked through a guard tube to prevent the dry surface soil from falling into the hole. The guard tube is a piece of brass tubing about one foot long, sharpened at one end, driven into the ground to a sufficient depth.

A few of the samples were taken at 0 to 6, and 6 to 12 inches but the most of them were taken in one foot sections, and to a depth including the sixth foot. The samples were taken to that depth in order to find out how far down the irrigating water percolated.

The samples were usually taken the day before irrigating and when taken on the same day then before the water was applied.

The sections as bored out were thoroughly mixed on a piece of oil cloth, or in a tin bucket, and a tin can filled and taken to the laboratory. The cans used are the half pint cans ordinarily used in the trade for paints, these are coated on the inside with asphalt varnish before using.

In the laboratory these samples were mixed again and 50 grams of each were weighed out into a dish. These dishes containing the samples were placed in an oven and heated to about 115° C from about 7 p. m. until 8 a. m. when they were cooled and reweighed.

The percentages of moisture are calculated to dry weight of soil. For example—25 per cent of moisture means that for every 100 parts of dry soil there are 25 parts of water.

SEEDING AND HARVESTING

The ground was plowed and put in condition for seeding between December 31, 1902 and January 3, 1903. The ground was rather cloddy but there was an ample amount of fine soil with which to cover the seed. The wheat used was Algerian White, Station No. 410,—a bearded variety with large white kernels and heavy straw. It was sown on Jan. 6, 1903 at the rate of 6 pecks per acre with a press drill, from 1½ to 2 inches deep, the drills being 8 inches apart. Borders were thrown up and the whole field was irrigated on Jan. 8. The field was not irrigated again until April 27, when the irrigation experiments began.

The wheat was harvested with a Champion self-binder on July 3rd. The grain was standing up well over all the field, and therefore there was little waste in harvesting.

It was threshed with a three horse-power machine, made by Heebner and Sons, Lansdale, Pa. The machine was cleaned after running through the product of each plat.

IRRIGATION

Heading Test.—Plats 3, 5, 6, 11, 12, 13 and 14 were irrigated on April 27 and on May 18, when they were beginning to head.

Plat 13 was then irrigated every third day until June 23, except on June 11 and 14 when it was very wet from rain.

Plat 12 was then irrigated every fourth day until June 23, except on June 11 and 15.

Plat 5 was irrigated every fifth day, except June 12 and 22 when it was wet from rain.

Plat 14 every sixth day, except June 11.

Plat 11 every eighth day, except June 11; it received its last irrigation on June 19.

Plat 6 every tenth day until June 7 after which it was wet from rain.

Plat 3 every twelfth day, except June 11.

Remainder of Plats.—Plats 21 and 22 were irrigated once a week from April 27 to June 22, except on June 15.

Plats 23 and 24 once in two weeks from April 27 to June 1. They were not irrigated on June 15 because of the rain. These plats also received an irrigation on May 18 by mistake.

Plats 1, 2, 17, 18, 19 and 20 once in three weeks from April 27 to June 8.

Plats 15 and 16 once in four weeks, on April 27, May 25 and June 22.

Plats 9 and 10 once in five weeks, on April 27 and June 1.

Plats 7 and 8 once in six weeks, April 27 and June 8.

RAIN

The rainfall for the season was as follows:

April .08 inch, May .1 inch, June 3.65 inches.

From the first to the sixth of June there was .24 in., on the tenth .01 in., on the eleventh there was 2.43 in., on the twelfth there was .78 in., on the fourteenth .14 in., and on the seventeenth .05 in. This heavy rainfall, just when the wheat was filling, seems to have been sufficient to make the crop fill on all of the plats in spite of the small amount of water that some of the plats had previously received, and thus spoiled the experiment as far as comparative yields are concerned.

NOTES ON CONDITION OF THE CROP

The general condition of the crop from the time it began its marked growth in spring until it was ripe is shown in the following notes:

May 18.—Plats 21 to 24. Wheat in good condition but slightly yellowish in color. The other plats have good color.

May 25.—Plats 21 to 24 still yellowish.

June 1.—The color of plats 21 to 24 is nearly normal, but the plants are not so tall as those of the other plats. Plat 21 is somewhat taller than 22 and 23, and 24 is also a little taller than these. On plat 26, which had not been irrigated since

April 27, wheat taller and more rank throughout than on any other plat. On plat 25 the wheat is a little taller and heavier than on any other plat except 26. Heading test plats are not noticeably different from the others.

June 8.—No change in appearance.

June 15.—No change.

June 22.—All of the wheat turning a little. Plats 21 to 24, which received most water, show least ripening. Plat 17 almost ripe. On plat 4 much of the wheat is ripe but poorly filled. This plat received too much water, due to the water breaking in on it from the plat of oats on the south at the time of the heavy rain, June 11; and because of this the data for this plat are omitted from the table. The grain now in thick milk stage.

June 29.—Wheat all ripe enough for cutting except plats 21 to 24. West quarter of plat 26 dead ripe.

RELATION OF NUMBER OF IRRIGATIONS TO SOIL MOISTURE AND YIELD

"The effects of different numbers of irrigations on the yield of wheat, especially the effect of frequent irrigations from the time of heading until the crop begins to ripen;" and "The relation between the number of irrigations, the amount of moisture in the soil and the yield", will be discussed together in this section.

In the following table the plats are arranged according to the number of irrigations received. The average percentages of moisture in the first two feet only are given in order that the results may be compared with those of previous years. The yields of grain and straw are calculated to pounds per acre, and the grain is also given in bushels per acre (60 lbs. = 1 Bushel).

Table 1.—Relation of Number of Irrigations to Moisture Content and Yield

Once in three weeks till heading				
Plat No.	Average per cent of Moisture in first two feet	Yield		
		Straw	Grain	
		Lbs. per Acre	Lbs. per Acre	Bushels per Acre
Then every third day				
13	26.0	2348.8	1417.2	23.6
Every fourth				
12	25.9	3240.5	1714.5	28.6
Every fifth				
5	28.0	2495.2	1328.8	22.1
Every sixth				
14	25.5	910.5	1330.8	22.1
Every eighth				
11	24.0	2382.8	1484.3	26.7
Every tenth				
6	21.8	1590.4	1153.8	19.2
Every twelfth				
3	21.7	2336.5	1464.1	24.4
Once a week throughout				
21	29.4	2213.2	1226.2	20.4
22	33.1	1416.8	771.3	12.8
Average..	31.3	1815.0	998.8	16.6
Once in two weeks throughout				
23	31.0	2307.7	1153.8	19.2
24	31.9	3436.5	1600.0	26.6
Average..	31.5	2872.1	1377.3	22.9

Table 1.—Relation of Number of Irrigations to Moisture Content and Yield.—*Continued.*

Plat No.	Average per cent of Moisture in first two feet	Yield		
		Straw	Grain	
		Lbs. per Acre	Lbs. per Acre	Bushels per Acre
Once in three weeks throughout				
1	19.0	918.0	781.5	13.0
2	19.8	2290.5	1504.2	25.1
17	24.6	3078.9	1659.5	27.6
18	23.9	2644.2	1562.5	26.0
19	23.2	2062.3	1373.0	22.9
20	21.9	2102.6	1448.6	24.1
Average..	22.1	2182.7	1388.2	23.1
Once in four weeks throughout				
15	22.3	1855.3	1171.6	19.5
16	24.0	2920.1	1628.0	27.1
Average..	23.2	2387.7	1399.8	23.3
Once in five weeks throughout				
9	21.8	2904.7	1590.4	26.5
10	19.2	2231.8	1545.0	25.7
Average..	20.5	2568.2	1567.7	26.1
Once in six weeks throughout				
7	18.6	2100.4	1278.5	21.3
8	19.1	2591.1	1457.5	24.3
Average..	18.9	2345.7	1368.0	22.8
Not irrigated after April 27. Rain made them receive practically the same amount of water as Plats 7 and 8				
25	....	1748.5	1098.8	18.3
26	....	2645.3	1557.3	25.9
Average..	....	2196.9	1328.0	22.1

Of the plats in the heading experiment those irrigated every fourth and every eighth day gave the highest yields, 28.6 and 26.7 bushels respectively: those irrigated every twelfth and third day come next with 24.4 and 23.6 bushels; every fifth and sixth day yielded 22.1 bushels each.

The plats irrigated once in five weeks gave the largest yield in this series, which was 26.1 bushels; once in four weeks next with 23.3 bushels; once in three weeks next with 23.1 bushels,—if we omit the yield of plat 1 then this group ranks second with an average of 25.1 bushels; then once in two weeks with 22.9 bushels; then once in six weeks with 22.4 bushels,—this includes plats 25 and 26 as the rain was practically equivalent to an irrigation; and last those irrigated once a week with 16.6 bushels.

The plats irrigated once in five and once in three weeks gave a larger yield than those irrigated every twelfth and third day after heading.

Those irrigated once in four, two and six weeks gave larger yields than those irrigated every fifth and sixth day after heading.

When the yields of straw are compared they are found to be as variable as the yields of grain.

On comparing the moisture content and yield we find that plat 7 with an average of 18.6 per cent. gave 21.3 bushels; plat 1 with 19.0 per cent. gave only 13 bushels, while plat 8 with 19.1 per cent. gave 24.3 bushels and plat 2 with 19.8 per cent. gave 25.1 bushels.

Plat 12 with 25.9 per cent. of moisture gave the highest yield of grain, 28.6 bushels while plat 24 with 31.9 per cent. of moisture gave the highest yield of straw, 3436 pounds; plat 22 which had 33.1 per cent. of moisture gave the lowest yield of grain, 12.8 bushels, and a low yield of straw.

These average percentages of moisture probably represent the average of the minimum amounts rather than the true averages since the samples were taken just before irrigation.

In order to obtain the true average samples should be taken soon after irrigation as well as just before. It might also be advisable to sample once in two weeks, or oftener where the plats are irrigated less frequently than once in two weeks. These points will be studied during the coming season.

These results indicate that the heavy rain on June 11, and the other showers near that time, supplied enough moisture to make the wheat fill nearly as well on the plats which had received least irrigation as on those that had received much more water.

They also lead us to believe that if enough moisture is supplied to keep the wheat growing until it begins to fill and an abundance of water is given at the time of filling, or just before, that the yield will be practically as great as if the soil had been kept quite moist throughout the growing season.

The idea that water applied before filling will not take the place of water at that time is one worthy of the consideration of the farmers in the Mesilla Valley. There is nearly always sufficient water in the ditches to make early ripening wheat fill, while late ripening wheat is sometimes caught by a shortage of water at this critical time.

The yellow color, for part of the season, and the lighter yield of grain on the plats irrigated once a week and once in two weeks indicates that they received too much water, which interferred with the aeration of the soil and possiblyalso with the production of nitrates in the soil. Plat 24, however, gave a heavier yield of straw than any other plat, while that of plat 23 was about an average. In the plats containing 30 per cent. of moisture the soil was about three fourths saturated, which is evidently too much moisture to maintain thoughout the season, and its probable that an average of 20 per cent. for the entire season is too low for producing a good yield on this soil.

These results also show that an excess of water at the time of filling retards the ripening of the grain.

The results of this season, and those of previous years with corn, show that the soil moisture is only one of the factors which govern the yield of crops and that the other factors are really more important than the moisture provided that the amount of moisture is sufficient to keep the plants from wilting and not great enough to saturate the soil. It is almost impossible to state what these other factors are but available plant food is probably one of the most important of them.

PERCOLATION

It is not thought necessary to give the moisture content below the second foot in detail as the amounts show much variation, due to the variable character of the soil at these depths.

The plats are underlaid by sand which in a few places appears as a fine loamy sand in the third foot and in all cases the fourth foot is a very sandy loam or pure sand; the fifth and sixth feet are in all cases nearly pure sand. Occasionally there are thin layers of clay in the sand, but these are not thick enough to prevent the water from passing down, as is some times the case in the soils of this valley. This slight admixture of clay with the sand in a sample is, however, sufficient to cause the moisture content of the samples to vary considerably.

Comparing the amount of moisture found on April 4, when the first samples were taken, with that present on July 1, we find that plats 4, 5, 12, 13 and 22, which received the greatest number of irrigations, show a decided gain in the total moisture in the third, fourth, fifth and sixth feet—2 to 10 per cent., an average of .5 to 2.5 per cent. per foot. Plat 2 also shows a marked gain, including the fifth foot, for which we do not see the season. Plat 21, which we would also expect to find in this group, shows a loss. The remainder of the plats all show a loss, which varies from 2 to 15 per cent. for the four feet, or an average of .5 to 4 per cent. per foot. The greatest variations are found in the third and fourth feet and the least in fifth and sixth, because the latter are nearly pure sand.

The results indicate that very little of the water passed beyond the fourth foot and in some cases the most of it was held in the first three feet.

These tests were merely preliminary and this subject will receive further attention during the coming season.

AMOUNT OF WATER APPLIED

It was our intention to measure all of the water applied to the plats. For this purpose a two foot weir was installed and a water register purchased.

The fall being so slight between the main canal, and the pump, and the plats it was necessary to make the ditch banks quite high above the weir. These banks being new gave trouble and also between irrigations the gophers worked in the banks and caused them to leak.

The clock of the register, as purchased, moved the pen an inch a day across the sheet and this was found to be too slow as the height of the water in the ditch fluctuated rapidly. Another clock was obtained which moved the pen an inch an hour; this caused a delay of several weeks.

Because of the trouble with the ditches and the delay in getting the register in working order but few measuments were made.

May 18 all plats, except 7, 8, 9 and 10, were irrigated, giving an area of 1.3 acres, and the water applied was sufficient to cover this area to a depth of 5.5 inches.

On May 25 plats 15 and 16, area .2 acre, received 3.3 inches of water.

May 26 plats 11, 12, 21 and 22, with an area of .3 acre, received water to a depth of 4.2 inches.

June 8 plats 1, 2, 7, 8, 13, 17, 18, 19, 20 and 21, an area of .8 acre, were irrigated and received water to a depth of 5.5 inches.

The irrigating was done by an experienced Mexican irrigator who handled the water according to his judgment.

The moment the water entered the first plat and the time at which it was turned into the waste ditch were noted on the register sheet.

We hope to obtain more complete data during the coming season.

BULLETIN NO. 49

DECEMBER 1903

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

CAÑAIGRE

BY

R. F. HARE

SANTA FE, N. M.:
NEW MEXICAN PRINTING COMPANY,
1904.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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SUMMARY

1. Cañaigre, unlike most plants, makes its growth during the winter season, from about the first of October to the first of April. It requires only about one-third the water required by many cultivated plants. The fact that we usually have an abundance of water during the winter, and a limited supply at other seasons, makes Canaigre a crop well suited to New Mexico.

2. At present it is more desirable to propagate cañaigre from the roots. The buds appear only on the crown, and it is not necessary to plant the whole root, about two inches of the crown section being sufficient. In this condition it may be planted successfully with a potato planter.

3. It has been found best to harvest cañaigre every two years: and in cases where the growth has been slow, and the yield would be small, it may not be necessary to harvest oftener than once in three years.

4. The stems and leaves of cañaigre are frequenty killed to the ground by severe frosts in this climate, but the roots usually occur at a sufficient depth to be protected, and new shoots are formed almost immediately after the ground has thawed.

5. Estimating ten tons per acre for a biennial crop, at the present market price, a net income of $26.50 per annum would be produced from one acre of cañaigre.

CANAIGRE

(Rumex hymenosepalus.)

So many inquiries concerning Cañaigre come to this Experiment Station that we have decided to summarize some of the facts obtained here, together with such as we have been able to obtain elsewhere, and publish them for the benefit of those seeking information relative to this plant. The Arizona, California and Texas Experiment Stations, especially the Arizona Station, have done much work with cañaigre, and many of the facts here given, are taken from their bulletins and annual reports. We are indebted to Prof. Forbes of the Arizona Station for the methods of analysis used.

The name "cañaigre" is thought by some to be a corruption of the Spanish "*caña agria*" (sour cane), and to have been anglicized in this form. It is now found in the Century and Standard dictionaries where the pronunciation "Ka-ná-ger" is given. This would seem to indicate that it has come into the English through the French "*canne aigre.*" In this part of the country, however, the word is pronounced "*Kan-yegh-gray,*" and this seems to be the most logical pronunciation if the word is of Spanish origin.

Cañaigre is a plant characterized by the high percentage of tannic acid contained in its roots. The leaves are said to have been used to some extent by the Indians as food, while the roots were used by them as medicine, and in a crude way for tanning hides and skins. The roots are at present being used in the preparation of tannic acid, dyes, and mordants, but their most important use is as a tanning agent. A tannin is any substance that will unite with the gelatin of raw hides and convert the dried skin into an insoluble, imputrescible, tough and flexible condition called leather.

SOURCES OF TANNIN

There are a number of sources, both organic and inorganic, from which tannins may be obtained. A few of the most important of these are mentioned below for the purpose of comparison with this plant.

Inorganic or *mineral tannin* is usually common salt with some salt of iron, chromium or aluminum. Mineral tanning, or tawing, as this process is usually called, produces leather inferior in quality to that produced by vegetable tannins, and is not in common use except in the tanning of hides with the hair on, when the use of vegetable "tans" would effect the color of the hair.

Fats and oils are sometimes used for tanning small hides. They produce a very soft white leather, which is used in making wash-leather, gloves, and for other purposes where a soft white leather is desired.

Artificial tanning materials have been prepared by the action of certain of the mineral acids upon finely ground peat, coal, or some similar material, but their use so far has been very limited.

Tanning, in the general acceptation of the word, means the treatment of hides to form leather with an extract, or infusion of some plant, which contains a vegetable tanning material.

There are other substances in the plant besides the tannic acid, which take part in forming leather, and all such substances are designated as "tannins." They seem to have no definite chemical composition, but their presence in the plant may be readily determined by its astringent taste, by the precipitate which an infusion of the plant forms with gelatin, or by the blue or green compound it forms with chloride of iron.

While a number of plants contain some tannin, only a few contain it in sufficient quantity to permit its use as a source of the commercial product. It is found concentrated in certain parts of the plant, and usually only those parts containing the most tannin are used. It may prove of interest to mention in this connection some of the most important plants and parts of plants which are of commercial value on account of the tannin they contain.

The *hemlock* and *oak* trees, in which the tannin is found principally in the bark. Probably 85 per cent of all the leather tanned in the United States is tanned either with oak or hemlock bark. This is not because the bark of these trees contains such a large quantity of tannin, for it rarely, if ever, exceeds 20 per cent., but because of the abundance of oak and hemlock in our large forests. In time this supply will become exhausted, or at least diminished to such an extent that the tanners will be compelled to look for another source. This will doubtless be some cultivated plant, and at present cañaigre seems to be a somewhat promising one for the purpose.

Nut galls, excrescences formed by the puncture of gall flies on oak trees, are an important source of tannin. They are the richest in tannin of all tanning materials, containing frequently from 60 to 70 per cent. They are found in the United States, but are not a commercial product here. Asia Minor, Turkey and Japan furnish the chief supply. The limited amount of galls would prevent their complete substitution for oak and hemlock bark.

Sumach is another important source of tannin, which is found principally in the stems, leaves and blossoms of the plant. Sumach is said to produce a very superior quality of light colored tough leather, but this leather does not resist water very well, nor is it well suited, when used alone to make sole leather, since the sumach does not add weight. For sole leather the sumach is mixed with oak or hemlock bark. It contains from 16 to 20 per cent. tannins.

The bark of numerous species of *Acacia* (Wattle-bark) is also used to some extent in tanning, but it is said to produce leather of inferior quality. It has been experimented with to a certain extent at the California Experiment Station. They found that while the the percentage of tannin was even higher than in cañaigre root, it took eight years to produce a crop, and this crop was hardly equal to the amount of cañaigre which could be grown during that period.

The *roots* of a few plants furnish a source of tannin. Ratahny and cañaigre roots frequently contain over 30 per cent. Ratahny is a South American plant. Its roots are rich in tannin, but so far it has not been an important source of this material.

CANAIGRE, ITS PROPAGATION AND CULTIVATION

Cañaigre is a species of yellow dock, sometimes called wild rhubarb. It has large, smooth, dark green leaves. In the spring an erect succulent flower stem appears, which is two feet high or less. Where the plant has grown without water, the stem seldom appears. Where it is given water in abundance, it is frequently more than two feet high. Last spring, because of the heavy rains, the plants on the mesa near the college produced a flower stalk, and on some of them mature seeds were formed. The roots form themselves in clusters around the parent root. When young they somewhat resemble sweet potatoes or dahlia tubers, but as they grow older they are much harder and darker in color. Thin transverse sections of the roots show concentric rings which are said to be annual rings of growth. The number of rings will give approximately, if not accurately, the age of the root.

Cañaigre is a winter plant and makes its growth from October to April. The Arizona Experiment Station Reports state that it grew more rapidly in Arizona during the four winter months when the temperature averaged about 53° F. The plant has a remarkable power of resisting drought. The fact that it grows wild on our table lands, above the irrigation level, shows this. Its drought resisting power and its adaptation to long and comparatively mild winters, make New Mexico and all of the semi-arid southwest, its natural home. It has been planted in Kansas, New York, North Carolina, Florida and other states, but while it is reported to have lived and withstood the severe winters of the North, the roots made a very slow growth. In Florida and eastern Texas it is reported to have been grown with success.

Cañaigre may be propagated in three ways; first, from the seed; second, from the roots; third, from the transplanting of young shoots.

Results both at this and the California Stations, show that plants, which have been cultivated and given plenty of water, will produce seeds which germinate without difficulty. At present, however fertile seed cannot be purchased, and the roots are planted exclusively. Propagation from the root is not so unsatisfactory, however, for in planting a root, it is not lost, as is the case with the potato. On the contrary, it grows larger and richer in tannin, besides performing its work of reproduction. Sections may be planted instead of using the whole root. The bud appears only on the crown, hence either transverse or longitudinal sections may be made. In case of transverse sections, only the crown part is used. In planting this top section, the California Experiment Station produced about four times as much new growth as was produced in planting whole roots.

Mr. J. J. Jacobsen of Faywood, New Mexico, who has grown cañaigre successfully for the past eight years, advises the planting of transverse sections, using about two inches of the crown part. The crowns may then be planted with any successful potato planter, which is impossible with the whole root on account of its length. A considerable saving, too, may of course be effected in this way, since the remaining part of the root may be chipped and marketed.

Bulletin No. 14 of this Station advises planting the old roots, but no reasons for so doing are given by the author. Experiments both at the Arizona and California Stations show that the young roots are more productive and grow faster, while the old roots contain more tannin and are better suited for marketing. Mr. Jacobsen advises planting healthy, vigorous roots, which have an abudance of buds, as each bud from the seed root produces another root. The roots may be planted at any time during the year. They are apparently not affected by heat or cold so long as they are well covered, but lie dormant until the proper season for their growth, provided they are planted deep enough to protect them from a severe frost. This, in my opinion, should be at least six inches. Roots planted in October on the mesa were covered with about three or four inches of earth. Since that time no rain has fallen to pack the soil around the roots, so that the wind has blown the sand away and exposed them, and those not covered with over two inches of soil have been killed by the frost. Roots, planted on the farm and irrigated, have fared better, but even those were frozen where no soil protected the crowns. Those well protected have formed young sprouts, which in some cases are now (Jan. 15, '04) two inches long. Young shoots which were transplanted at the same time, are all growing vigorously now, but their leaves have been killed almost to the ground by the frost. The leaves have also been killed on old, well established plants, both on the mesa and on the farm, a fact which no doubt affects the plants growth to a considerable extent.

From April first to July first is the most desirable time for planting, since at that time the buds are dormant, and there is no danger in breaking them off in planting, as would be the case if they were planted in the fall. When a field is once planted, enough roots may be left in the ground for the succeeding year's growth, if they are harvested by hand; but this is not practical when harvested with mrchinery.

Cañaigre has been successfully propagated by the setting of young sprouts, as in the case of sweet potatoes, but by this method it would take one year longer to make a crop equal to that produced from roots.

CULTIVATION

It is generally directed that the cañaigre be planted in rows thirty inches apart with the plants ten inches apart in the row. Mr. Jacobsen says that it may be planted with a regular potato planter in ground prepared in a manner similar to that for potatoes. He thinks that in the Mimbres valley, where the soil is chiefly a loose sandy loam, it should have three irrigations, followed each time by a two-horse cultivator. The fact that the plant can be harvested at the convenience of the planter, is an important factor in its culture. From April to October, when there is no growth above ground to interfere, is, of course, the most convenient time to harvest; but the sprouting of the roots in winter does not cause a loss of tannin, and if more convenient they may be harvested at that season. However, the percentage of soluble non-tannins, which are often objectionable in tanning, is reported to be less during the dormant season.

ENEMIES

Large white worms, the larvæ of some insect or insects, are destroying a good many roots on Mr. Jacobsen's plantation, but he thinks that only the older roots, which should have been harvested earlier, are affected by the worm. No attempt has been made here to determine what the insect or insects are, but they are probably the Lamellicorn, or June beetle, mentioned in the Arizona Reports as being enemies of cañaigre. The cañaigre beetle, referred to as doing considerable damage in Arizona, has not been observed here. Some animals, probably skunks or weasels, do more damage than the worm itself by scratching up the entire hill in search of the worm.

YIELD PER ACRE

No accurate experiments to determine the yield per acre of cañaigre have ever been made here. About ten years ago the Agricultural department planted some roots on the college farm, and also in a few acres above the irrigation level just back of the college buildings. Bulletin No. 14 states that from four to ten tons per acre were obtained on the college farm. Nothing definite is said relative to the yield obtained on the mesa, but it was probably rather small. The plants on the mesa are still alive and growing, and if they were harvested now, would yield about ten tons per acre.

It is difficult to say just how many years they have been in producing this amount of roots. In order to determine this point, other experimental plats were planted on the mesa Oct. 9th of last year, with a view to determine their annual yield, but, as noted above, most of the roots planted have been killed by the frost and will not be replanted this winter. Plats have also been planted in the adobe soil on the college farm for the purpose of more accurately determining both the annual and biennal yield there.

Concerning the yield, Dr. Hilgard (Cal. Rep. '94 to '95, says, "A crop of ten tons per acre is probably a fair average expectation."

Bulletin No. 38 of the Texas Station, states that "much depends on the selection of seed roots for planting, time in which they are planted, preparation of land before planting, and care taken of the crop, after planting what the yield will be. From my own experience one pound to the stand or plant of new roots one years growth is the lowest possible average. This would yield, in beds three feet apart and ten inches in drill, 17,640 pounds. This yield can be doubled if all the above points are strictly observed."

Mr. Jacobsen states that his yield is about seven tons for an annual crop, and fourteen to sixteen for the biennial.

Test plats at the Arizona Station yielded only two and one-half to three and one-half tons for an annual crop, and six tons for the biennial crop. The probabilities are that these results are below the average, and with proper conditions a yield of from five to seven tons may be expected for the annual crop, and from twelve to sixteen for the biennial crop. It seems to be the general consensus of opinion that it should be harvested only biennially, since the plant grows quite slowly. It increases in tannin during the second year, and, moreover the weight of the one year old root is almost doubled. It may be, that when more is known concerning varieties, methods of cultivation, character of soil for planting, etc., a much larger yield will result. A number of hills, dug at random on the farm of Mr. Jacobsen contained over fifty roots each.

In one case, eighty-two sound roots, weighing in all ten pounds and seven ounces, were obtained from one hill. When planted as directed above, this would be equivalent to a yield of over eighty tons per acre. This, of course, is far above the average, but it is interesting in showing the possibilities in yield. The exact age of this hill is not known, but it was probably four or five years old.

PERCENTAGE OF TANNIN

There is considerable variation in the amount of tannin found in different samples of cañaigre. While analyses show all the way from 15 to 42 per cent. in the air dried roots, from 25 to 30 per cent is probably about the average. The average of thirty samples grown in California was 27.7 per cent. Nine carloads from Arizona averaged 30.84 per cent. The percentage of tannin in samples analyzed at this station varies from 15 to 38.81 per cent. This wide variation is attributed to several causes. First of all, much depends upon the age of the roots. Up to the time they are one year old the tannin increases rapidly. For example, very young roots, probably one to two months old, analyzed by this station, showed only 0.96 per cent. tannin. The following results for roots of different age are selected from a table of analyses made at the Texas Experiment Station: Roots four months old 9.16 per cent., five months old, 10.8 per cent., six months old, 15 per cent., ten months old, 20 per cent., one year old 25 per cent. The tannin increases gradually from one year until the roots are four to five years old. At the Arizona Experiment Station the average increase of tannin from year to year in ten experiments was shown to be 1.64 per cent.

Local conditions also affect the percentage of tannin in the roots. To make tannic acid, the plant must have sunshine. Two plants were analyzed here, which grew near each other and under the same conditions, except that one had sunshine, while the other was almost completely shaded. They contained 23.98 per cent. and 15.09 per cent. of tannin respectively. A correspondingly low amount of tannic acid was also obtained in plants which had but little sunshine at the Arizona Station.

No doubt the percentage of tannin in cañaigre would also be affected to some extent by climatic conditions, as is the case with sugar in sugar beets.

The California Station characteristically claims superiority for California grown cañaigre. They report that the highest percentages obtained by them arrange themselves in the following order: California 41.2 per cent Arizona 34.98 per cent Florida 28.73 per cent. However, an average of thirty samples of California grown cañaige, one year old, showed only 27.7 per cent. tannin, which is not above the average of roots grown in New Mexico and Arizona. The probabilities are that roots with a high percentage of tannin can be grown anywhere in the semi-arid southwest. Cultivation and irrigation, while increasing the yield, do not seem to materially affect the amount of tannin. They probably will reduce the non-tannins and objectionable coloring matter. No doubt cultivation and judicious selection will, in time, improve both the quantity of tannin and quality of the roots.

VALUE OF CANAIGRE FOR TANNING

The value of a tanning material does not depend alone upon the percentage of tannin obtained. It must also be a material that will tan quickly, and produce a soft, light colored leather that is impervious to water, and little affected by moderate heat. In case the leather is to be sold by the pound, it must also add weight.

There seems to be some difference of opinion in regard to the value of cañaigre tannin. Some consider it an inferior tanning agent, but the general opinion with practical tanners seems to be that it is a quick tanner, and one producing a soft, durable leather.

Concerning cañaigre tannin, Circular No. 20 Dept. of Agriculture says, "The coloring matter is objectionable to a certain degree, and it cannot be used for heavy leather, such as sole leather or belting." If, as is claimed, cultivation reduces the coloring matter, it would overcome the first objection to some extent. If a heavy leather is desired from cañaigre tannin, it might be of advantage to use canaigre high in starch and non-tannins, since these are said to enter the hide and help to add weight; or the cañaigre may doubtless be used together with oath bark, as is often the case with hemlock, when it is used for making sole leather. Many practical tanners say they would use cañaigre exclusively, if it could be obtained continuously, but it is, of course, not convenient to change from one tanning material to another.

Mr. C. B. Allaire, who was President of the Deming Tannin Extraction Co., says he has received testimonials from practical tanners all over the worlds who speak in the highest terms of its value. He adds that a market is already established for all the cañaigre that can be grown.

IS CANAIGRE A PROFITABLE CROP FOR NEW MEXICO

If there is a demand for the product, and a fair yield can be produced, then the important point to be determined is whether or not it can be profitably grown in New Mexico.

For the past twelve or fourteen years, some cañaigre has been shipped from the territoy. The first put on the market was shipped green. On account of the high freight rates, as well as the fact that green cañaigre rots in piles, this method was followed by chipping and drying the roots before shipping. The gathering of the wild roots and their preparation in this manner for the market became quite an industry at several points in the southwest. But the plant occurs growing wild in relatively small patches, scattered over a wide territory, and in a short time, all that growing in the vicinity of the railroads was harvested, and in nearly every instance, the industry has been abandoned.

A number of companies have been formed for the purpose of cultivating cañaigre, but they too have generally failed. We are inclined to beleive that this was in part due to the bad management of the companies; or to a lack of knowledge of the proper soils, climate, methods of propagation, cultivation, etc. We have been informed that one company planted a carload of frozen roots, and became discouraged because no yield was obtained. Some failures are to be expected in any new enterprise. They were not uncommon in the early history of sugar beet culture, and are to be expected in the culture of cañaigre until more is known concerning the plant.

Probably the only company at present cultivating cañaigre in New Mexico is the one located on the lower Mimbres river, near Deming, for which Mr. Jacobsen is manager. He chips and dries the roots before marketing. They are chipped with an ordinary root slicer, which has a capacity of about twenty tons per day. The sliced roots are spread out on sheets in the sun and dried until they can be crushed in the hand, when they are sacked, and are then ready far the market. They are at present receiving $30.00 per ton, f. o. b. their railway station for the roots in this condition. At this rate, if for a biennial crop they can raise ten tons of green roots, which is equivalent to three and three-fourths tons of dried chips, they would receive $112.50 per acre every two years. The cost of producing the green roots and preparing them for market should not exceed six dollars per ton (an estimate higher than the one usually given.) At this rate the company would net $52.50, or at the rate of $26.25 per annum.

Cañaigre is said to be an unfailing crop, and one that can be counted upon, even in case of a shortage of water.

At the present price of alfalfa, New Mexico farmers will probably be slow to abandon this crop for cañaigre, at least in places where an abundance of water can be obtained: but since cañaigre does not require over one-third the water required by most crops, and this water is needed during the winter season, when there is generally an abundance in New Mexico streams, it may some day prove a valuable crop here.

BULLETIN NO. 50

FEBRUARY 1904

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

STEER AND LAMB FEEDING

BY

J. J. VERNON

SANTA FE, N. M:
NEW MEXICAN PRINTING COMPANY,
1904.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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SUMMARY AND CONCLUSIONS

1. Present range methods are wasteful. The grass over large areas is destroyed by close cropping and much tramping. Over-stocking is universal and not likely to be corrected under the present system of handling free public range.

2. It is believed that the price of range stock would be higher and the revenue from range areas would be greater by the introduction of a leasing system or other method whereby a given range area could be controlled for a definite period; by the infusion of better blood into the stock upon the ranges; by carrying two or more kinds of stock, such as cattle, horses and goats, under one management; and by the feeding of large numbers of range grown stock upon the valley farms.

3. The results of these experiments indicate that feeding steers and lambs for the local markets will prove remunerative so long as dealers will pay the same price for the home fed product that they must pay for the imported article of equal quality.

4. Beef and mutton, of a quality suitable for the local market demands, can be produced by feeding alfalfa hay alone. In these tests the addition of grain, though rather high in price, showed the following advantages over feeding alfalfa hay alone: the return per ton for the alfalfa hay consumed was greater, more rapid gains were made, the feeding period was shorter and a much better product was secured.

5. The lambs in these experiments gave a greater return per ton for the alfalfa hay fed than did the steers.

6. About one hundred days for lambs and five or six months for steers, is a sufficient time in which to fit them for the local markets, when fed on alfalfa hay alone. It will require less time when grain is fed with the alfalfa hay.

7. Frequent weighing, because of the unavoidable excitement, is probably not conducive to rapid gains with range grown steers.

INTRODUCTION

The experiments in feeding cattle and sheep, the results of which are recorded in the following pages, were conducted during the winters of 1901–2 and 1902–3. These experiments are the first of their character that have been conducted at this Station. However, considerable feeding has been done in some parts of the Territory, but so far as known, no records have been kept and information as to the results cannot be obtained.

There has been some demand in the past for information on feeding in New Mexico, and it is believed that the need for such information will be much greater in the future. Upon the completion of storage reservoirs and the development of irrigation systems, which will result in the reclamation of immense arid areas, the feeding industry will command much attention among farmers. There is little information available to the New Mexico farmer and ranchman upon feeding, and therefore, it is thought desirable to publish the data thus far secured upon this subject. The results obtained are suggestive of the possibilities,—the conclusions, however, are only tentative, there not having been a sufficient number of trials from which to draw them.

PRICES AND RANGE CONDITIONS

Uneasiness is felt among ranchmen in various quarters in regard to prices. Aside from the influences that cause the fluctuation from year to year of the general market, probably, the factor that operates most strongly in controlling prices, is the condition of the ranges, which, in a great measure, determines the quality of the product. The condition of a range in any case depends upon the local rainfall and the number of animals it is made to carry. Over-stocking is almost a universal practise. Under the conditions that prevail generally over the range areas of the Territory, stock must travel long distances between grass and water. This makes necessary a great amount of extra work, and therefore, a large portion of the food is consumed in work that otherwise might have gone to the production of flesh and bone, and to the making of an animal of much better quality. Over-stocking results in a smaller carcass and a poorer feeder, and so, a comparatively lower price must be accepted.

REMEDIES

There are several things that would assist in maintaining good prices for range grown stock if they could be made effective:

First. Individual ownership or individual control of range areas, probably, would be the quickest and most effective means that could be employed to this end. The present range methods are wasteful in the extreme in as much as the grass on large areas is practically destroyed by over-stocking. So long as free range exists, just so long will our ranges be over-stocked. The ranchman, for the sake of self-preservation, must protect his interests by preventing encroachments upon his chosen territory. Let him unwittingly allow his range to become strong just so soon does he tempt his neighbor, or invite a newcomer who has had no lessons in range courtesies, to divide the range with him. But with individual ownership or with the inauguration of a leasing system whereby an individual could control a given area for a specified term of years, self-interest in most cases, would operate against the present wasteful methods and a far better product could be secured.

Second. Raising the standard of the herd by the infusion of better blood and by sending to the butcher inferior individuals among the breeding herd. Progressive ranchmen have for some time availed themselves of such means for the improvement of their stock and it has had not a little influence in holding prices firm, aside from creating an additional revenue from the sale of breeding stock.

Third. Diversity in stock-raising by the introduction of more than one class of stock upon the range. This is not likely to increase the price received for individual animals but it will, where water is plentiful and the range large, greatly increase the total revenue. Cattle and horses form a good combination. The introduction of horses may almost double the range area for it is a recognized fact that horses do, with ease, travel twice as far for food and water as cattle. There is a tendency among some to turn much of their attention to the raising of horses or mules. If size be maintained, upon a good foundation stock, such an enterprise is likely to prove remunerative.

The angora goat industry is coming into considerable prominence. In fact the industry has made rather more than expected progress. Since goats prefer to browse upon the leaves, twigs, buds, et cetera, to be found abundantly among the rocks and cañons of the mountain ranges, they do not trespass upon the valley and plain. Cattle, horses and goats may be handled by one ranchman. Cattle feed near the water, horses range far out on the plains, while the goats seek the hilly and mountainous areas. None need trespass upon the territory of the other providing separate watering places are maintained.

Fourth. Feeding range grown stock upon the valley farms and ranches. This is the proposition in which we are interested in this bulletin and if feeding became general it would probably result beneficially in several ways: it would create an important avenue for the disposal of range stock; it would lessen the number of stockers that must meet competition from other sections in our large markets; it would afford the valley farmer an easy and convenient way to market large quantities of grain and forage; and further, our home markets could be supplied from the products of our own soil.

MARKETS

The stock grown upon the ranges of the Territory find three principle outlets:

1. The large eastern markets.
2. Ranges further north and in California.
3. The local markets.

Stock shipped to the Kansas City or Chicago markets must meet the competition from other sections somewhat more favorably situated as regards rainfall and freight rates. The demand for stock to be finished upon the ranges further north and in California is irregular, depending almost wholly upon the rainfall there. Local markets pay no more and often less than can be secured elsewhere. Local buyers discriminate little between classes for butchering purposes, and yet large quantities of the better class of meat are imported from Kansas City and from the cotton producing sections of Texas. Farmers who feed must either sell to the local dealers, often receiving a price low when compared with the price the dealers receive for the meat or ship to the packing-house markets. The latter, in many sections of the Territory, would prove unprofitable owing to the long hauls through a mountainous country under which condition the shrinkage would be heavy because of the long time spent in transit. The high freight rates through such a region and the competition from sections more favorably situated would further operate against shipping. These same conditions, however, should operate in favor of feeding for the local markets, at least, until the home markets are supplied, except when dealers taking advantage of the conditions pay less for the home fed product than they must pay for the imported article of equal quality.

Further, feeding should have a reciprocal effect upon the alfalfa market. Every ton of hay disposed of in the form of meat would leave just that much less to be sold on the open market. If one-half of the alfalfa hay of the valley were fed each year to cattle, sheep and hogs, the price of the other half through the effect of supply and demand would be enhanced. It would raise the price of hay in the same way that a half crop causes the price to rise. We have as an illustration the season of 1902, when the price of alfalfa hay rose to $15.00 per ton in March of the following spring.

Market quotations show that the price of stockers at the present time is at a very low ebb. This is caused in a measure, at least, by the high price of feed and the rushing to market of large numbers of poorly finished animals, thus glutting it with an inferior product. A reaction will eventually follow, and better prices will prevail. The outlook for the future in New Mexico is rather encouraging. Through the aid of the irrigation act the cultivated areas will be greatly increased in the next few years. This will result in an increase in the population,—largely agricultural, which will become consumers of meat and feeders of range grown stock. At the same time the range areas will be decreased by the amount of land brought under cultivation.

OBJECTS OF THE EXPERIMENTS

1. To determine whether feeding cattle and sheep for market in this and similar valleys of New Mexico is feasible.
2. To make a study of the feeds available in order to determine the best for feeding purposes under the prevailing conditions.
3. To determine the best class of range stock for feeding.

CONDITIONS AND EQUIPMENT

The mild winter weather prevailing in most of the valleys of New Mexico render unnecessary the expense of providing shelter for feeding stock, more than to supply a wind-break, which is necessary only when the feeding is to continue through the windy month of March. The wind-break may be constructed of the most inexpensive material,—a tight board fence or even a rick of corn or kafir-corn stover would serve the purpose admirably.

The feeding pens and the hay racks need not entail a great expense. When hay is fed from the stack it is a common practice to fence in a lot around the stacks, leaving an opening between the boards of the fence on the side next to the stacks through which the cattle or sheep, as the case may be, may secure the hay which is strewn upon the ground just inside. This method affords the greatest economy of labor and material in building the pens and racks, and furthermore, it provides a most convenient and labor-saving way of supplying the hay to the stock.

THE STATION EXPERIMENTS

The Feeding Pens.—The feeding pens for the steers were 16 feet wide and 32 feet long made of 2-inch by 6-inch pine lumber. The sheep pens were 12 feet wide and 40 feet long made of 1-inch by 6-inch pine lumber with a board shed 10 feet by 10 feet connected with each pen provided with an opening large enough for the lambs to enter.

The Racks.—The feeding racks for the hay for both the steers and the lambs were placed just outside of the fence at the end of each pen. The fence formed the front, the back was made of inch lumber and the ground formed the bottom. The boards on the fence were so placed as to leave a space through which the stock could reach the hay.

The Grain Troughs.—The grain troughs for the steers were 10 feet long, 2½ feet wide and 6 inches deep, supported upon legs of suitable hight. The grain trough for the lambs was 16 feet long, 10 inches wide and 4½ inches deep, with a strip running the whole length of the trough about 10 inches above the middle which prevented the lambs from getting into it while they were eating the grain.

Weighing.—The weights were all made with a pair of ordinary wagon scales which were located near the feeding pens. The scales were frequently tested. A chute connected the steer pens and the scales. Good water, which was kept before both the steers and the lambs all of the time, was drawn from a storage tank.

Waste.—The hay not consumed was weighed and deducted from the amount given. This waste was fed to stock cattle on the farm and it was practically all consumed by them. No account was taken of the food thrown out of the troughs and trampled under foot, and therefore, it is included with the amount consumed.

Labor.—No charge is made for the labor in feeding. It is believed that the labor connected with feeding the hay to the steers and lambs on the farm would be less than the cost of hauling it to the station and loading it in the car. The value of the manure if spread upon the land would go far toward squaring the labor account.

EXPERIMENTS WITH STEERS

1901–2

DESCRIPTION OF STEERS

The experiment was made with nine, long yearling steers purchased from Mr. J. D. Isaacks, of Las Cruces, New Mexico. The steers were raised on his range located in and west of the Organ mountains. The purchase was made in the fall, the regular round-up and delivery having been made late in the previous spring, and therefore, the steers were not as even a lot as was desired.

PRICE PAID AND RECEIVED

The price paid, $20.00 per head, was a little above the ruling prices, but it would have been impossible to buy so small a number for what they were really worth. The cost of riding the range and gathering a small number is nearly as great as it would be for gathering a much larger number. This of course cuts the profits somewhat but no reduction has been made on account of it.

The steers were in good condition for the local market when sold. They brought five cents per pound live weight on April 21st.

DIVISION

The steers were divided into three lots of three steers each as nearly equal in weight and quality as possible. Each lot was weighed at the beginning and once a week thereafter to the end of the test. The weighing was done at 2 o'clock p. m. The steers were handled quietly and after the first week or so they ceased to be unduly afraid of the feeder but were always nervous upon being removed from their pens for weighing.

FEEDS

The alfalfa hay was purchased in the valley at $7.00 per ton baled and delivered. Ten tons of it had been slightly bleached on top when in the wind-row before baling. Its feeding value was probably only slightly diminished by the bleaching, since only a small portion was affected, and yet it would not have gone on the market as first-class hay. The rest of the hay was first-class.

The corn and kafir-corn stover were raised on the Station farm and for the experiment were estimated at $4.00 per ton shredded. This is probably a little above the cost of production for the kafir-corn stover and considerably above the cost of corn stover. The corn stover was from a field of Hickory King corn which yielded about 25 bushels of grain per acre. The stover was shredded,—enough being shredded at one time to last about two weeks. The corn stover was badly bleached by rain when in the field. The kafir-corn stover was of an excellent quality when freshly shredded but it was found to deteriorate rapidly. It was found next to impossible to get it dry at this season of the year before it was attacked by mould. This rendered it more or less unpalatable and only a small quantity was consumed by the steers. Salt was kept by the steers all of the time.

Lot 1 was fed alfalfa hay alone.

Lot 2 was fed alfalfa hay and shredded kafir-corn stover.

Lot 3 was fed alfalfa hay and shredded corn stover.

THE FEEDING PERIOD

The test was begun on October 12th, 1901, and continued for six months and nine days, or 192 days, closing on April 21st, 1902.

MARKET DEMANDS

The local markets do not demand a finished product as does the packing-house markets. Local dealers are not prepared to profitably utilize the offal or the excess of fat from a well finished carcass, therefore, they prefer animals only about one-half finished. This class of meat can be produced without grain if the feeding period is long enough. Alfalfa hay alone produces meat that is rather soft and the addition of some grain will not only result in a better product but in the end will usually pay.

TABLES

It has been the purpose of the writer in making up the tables for this bulletin to present the data in such varied form that it can be easily studied by the feeder. This has made a number of tables necessary.

Alfalfa is the most important crop in New Mexico, and for that reason, it is likely to form a large part of any feeding ration. In the tables alfafa hay, besides being figured at the market price at the time of purchase, is also figured at the cost of production baled f. o. b. the car, and at cost in the stack on the farm. After alfalfa has been baled and stored low prices may render feeding it advisable. In sections where feeding has become an assured industry feeding from the stack has been found to be the best and most economic method, all things considered. Stacking hay when it is to be used for feeding has the following advantages over that of baling it in the field.

1. It costs less to produce the hay.

2. The alfalfa can be removed from the field sooner.

3. More of the leaves, the most nutritious portion of the plants, can be saved.

4. Water can be applied sooner after cutting, thus increasing the yield for the season.

Objections to stacking have arisen from the great waste that is common by this method of storing hay. The waste, however, can be minimized by the use of inexpensive stack covers which can be made of canvas or lumber or by building open sheds consisting of a roof supported upon tall telephone poles. The latter is the better wherever feeding, as an industry, is established.

Whether the hay is stacked in the open or under sheds, improved labor-saving machinery, such as loaders, stackers, forks, et cetera can be profitably used.

Table I.—Financial Statement

STEERS 1901-2

Showing the profit on each lot with alfalfa hay figured as follows: At the market price on board car, at cost on board car, at cost in the stack on the farm.

		Alfalfa hay, baled, at $7.00 per ton. Kafir-corn Stover and Corn Stover, shredded, at $4.00 per ton.		Alfalfa hay, baled, at $3.50 per ton. Kafir-corn Stover and Corn Stover, shredded, at $4.00 per ton.		Alfalfa hay, in stack at $2.50 per ton. Kafir-corn Stover and Corn Stover, shredded, at $4.00 per ton.	
		Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Lot 1.	By 3 steers, 2704.6 pounds live weight at 5c.		$135.23		$135.23		$135.23
	To 3 steers at $20.00 per head	$60.00		$60.00		$60.00	
	To 13987.5 pounds alfalfa hay	48.96	108.96	24.48	84.48	17.48	77.48
	Profit		$ 26.27		$ 50.75		$ 57.75
Lot 2.	By 3 steers. 2800 pounds live weight at 5c.		140.00		140.00		140.00
	To 3 steers at $20.00 per head	60.00		60.00		60.00	
	To 12228 pounds alfalfa hay	42.80		21.40		15.29	
	To 486 pounds kafir-corn stover	1.69	104.49	1.69	83.09	1.69	76.98
	Profit		$ 35.51		$ 56.91		$ 63.02
Lot 3.	By 3 steers, 2590.6 pounds live weight at 5c.		129.53		129.53		129.53
	To 3 steers at $20.00 per head	60.00		60.00		60.00	
	To 11572.5 pounds alfalfa hay	40.50		20.25		14.47	
	To 453 pounds corn stover	.90	101.40	.90	81.15	.90	75.37
	Profit		$ 28.13		$ 48.38		$ 54.16

Table I, besides showing the amount of the different kinds of food consumed and the net profit on each lot with alfalfa hay figured at its actual cost upon the local market, also, shows the net profit with alfalfa reckoned at the cost of production baled and stored and at cost in the stack.

Like information in regard to the lambs fed can be found in Table IX, and for the second trial with steers in Table XVI.

Table II.—Feeds Consumed

STEERS 1901-2

	Lot 1 Pounds	Lot 2 Pounds	Lot 3 Pounds
Total alfalfa	13987.5	12228.	11572.
Total kafir-corn stover	....	846.	....
Total corn stover	....	....	453.
Total feed	13987.5	13074.	12025.
Average daily roughage per head (192 days)	24.28	22.69	20.87
Average roughage per head per month (30 days)	728.5	680.9	626.3
Nutritive ratio	1:3.8	1:4.1	1:3.9

Table III.—Weights and Gains

STEERS 1901-2

	Lot 1	Lot 2	Lot 3
Weight at beginning of test	1920.	1942.	1920.
Weight at end of test	2704.6	2800.	2590.6
Total gain	784.6	858.	670.6
Average gain per head	261.5	286.	223.5
Average daily gain per head (192 days)	1.36	1.49	1.16
Average daily gain per 1,000 pounds live weight	2.13	2.30	1.82
Pounds food to make 1 pound gain	17.82	15.23	17.93
Pounds food to make 100 pounds gain	1782.	1523.	1793.
Cost of 1 pound gain*	$ .0624	$ .0518	$ .0617
Cost of 100 pounds gain	$6.24	$5.18	$6.17

* Alfalfa, baled, $7.00 per ton, kafir-corn and corn stover, shredded, estimated at $4.00 per ton.

Table IV.—Comparison, by lots, between the rations composed of Alfalfa; Alfalfa and Kafir-corn Stover; and Alfalfa and Corn Stover.

STEERS 1901-2

	Lot 1 Alfalfa	Lot 2 Alfalfa and Kafir-corn Stover	Lot 3 Alfalfa and Corn Stover
Total pounds gained	784.6	858.	670.6
Average gain per head	261.5	286.	223.5
Average daily gain per head (192 days)	1.36	1.49	1.16
Average daily gain per 1000 pounds live weight	2.13	2.30	1.82
Pounds roughage to make 100 pounds gain	1782.	1523.	1793.
Pounds roughage to make 1 pound gain	17.82	15.23	17.93
Cost of 100 pounds gain (*alfalfa hay at $7.00 per ton)	$ 6.24	$ 5.18	$ 6.17
Cost of 100 pounds gain (*alfalfa hay at $3.50 per ton)	3.12	2.69	3.15
Cost of 100 pounds gain (*alfalfa hay at $2.50 per ton)	2.23	1.98	2.29
Return per ton for alfalfa hay	10.71	12.81	11.86
Return per acre for alfalfa hay**	32.13	38.43	35.58
Cost of steers per head	20.00	20.00	20.00
Selling price per head	45.08	46.66	43.17
Cost of food per head (*alfalfa hay at $7.00 per ton)	16.32	14.83	13.80
Profit per head (*alfalfa hay at $7.00 per ton)	8.76	11.84	9.38
Cost of food per head (*alfalfa hay at $3.50 per ton)	8.16	7.70	7.05
Profit per head (*alfalfa hay at $3.50 per ton)	16.92	18.97	16.13
Cost of food per head (*alfalfa hay at $2 50 per ton)	5 83	5.66	5.12
Profit per head (*alfalfa hay at $2.50 per ton)	19.25	21.01	18.05
Average per cent. of dressed weight	53.24	52.12	51.30

* Shredded kafir-corn and corn stover, estimated at $4.00 per ton.

** Reckoned at an average yield of three tons per acre per year.

The results given in Table IV show the value of corn and kafir-corn stover when fed with alfalfa hay. In every essential point the results show that an addition to the alfalfa of a small amount of corn or kafir-corn stover forms a better ration than alfalfa hay alone. Both corn and kafir-corn stover have a wide nutritive ratio, while the nutritive ratio of alfalfa is very narrow; thus they tend to correct the ration of alfalfa, and to bring it nearer to the recognized standard for fattening steers.

Table V.—Return per Ton for Alfalfa Hay

STEERS 1901-2

Lot 1		
By 3 steers, 2704.6 pounds at 5c		$135.23
To 3 steers at $20.00 per head	$60.00	60.00
Balance to the credit of alfalfa hay		$75.23
Received for alfalfa hay per ton		**$10.71**
Lot 2		
By 3 steers, 2800 pounds at 5c		$140.00
To 3 steers at $20.00 per head	$60.00	
To 846 pounds kafir-corn stover at $4.00 per ton	1.69	61.69
Balance to the credit of alfalfa hay		$78.31
Received for alfalfa hay per ton		**$12.81**
Lot 3		
By 3 steers, 2590.6 pounds at 5c		$129.53
To 3 steers at $20.00 per head	$60.00	
To 453 pounds corn stover at $4.00 per ton	.90	60.90
Balance to the credit of alfalfa hay		$68.63
Received for alfalfa hay per ton		**11.86**

Tables V, XIII and XX show the return per ton for the alfalfa hay fed to the different lots in each experiment. The lambs gave a larger return per ton for the hay consumed than did the steers in either test. This is true, not only of the lots that received alfalfa hay alone, but it is also true of the lots that received other feeds in addition to the alfalfa hay, though the difference is not so great in the latter case.

Table VI.—Weights and Gains by Periods of One Week

STEERS 1901–2

Date	Lot 1		Lot 2		Lot 3	
	Alfalfa		Alfalfa and Kafir-corn Stover		Alfalfa and Corn Stover	
	Weight Pounds	Gain Pounds	Weight Pounds	Gain Pounds	Weight Pounds	Gain Pounds
Oct. 12, 1901......	1920		1942		1920	
" 19, "	1960	40	2038	96	1942	22
" 26, "	1982	22	2008	—30	1928	—14
Nov. 2, "	1968	—14	2100	92	1960	32
" 9, "	2120	152	2180	80	2020	60
" 16, "	2150	30	2158	—22	2040	20
" 23, "	2180	30	2240	82	2096	56
" 30, "	2232	52	2204	—36	2110	14
Dec. 7, "	2264	32	2230	26	2116	6
" 14, "	2186	—78	2252	22	2100	—16
" 21, "	2230	44	2244	—8	2094	—6
" 28, "	2250	20	2298	54	2140	46
Jan. 4, 1902......	2280	30	2296	—2	2108	—32
" 11, "	2340	60	2354	58	2210	102
" 17, "	2304	—36	2348	—6	2176	—34
" 25, "	2390	86	2415	67	2288	112
Feb. 1, "	2422	32	2492	77	2306	18
" 8, "	2482	60	2544	52	2348	42
" 15, "	2460	—22	2550	6	2370	22
" 22, "	2525	66	2556	6	2370	00
Mch. 1, "	2558	33	2620	64	2400	30
" 8, "	2552	—6	2612	—8	2446	46
" 15, "	2584	32	2636	24	2458	12
" 29, "	2602	18	2644	8	2482	24
April 5, "	2676	74	2690	46	2534	52
" 11, "	2600	—76	2720	30	2542	8
" 19, "	2726	126	2798	78	2616	74
" 20, "	2694	—32	2808	10	2582	—34
" 21, "	2694	00	2794	—14	2574	— 8
Average of April 19, 20, 21........	**2704⅔**		**2800**		**2590⅔**	

Table VI shows the weights and gains of each lot by periods of one week. The gains were fairly regular,—the apparent losses, probably, being due to the variation in the amount of water taken before weighing.

The almost universal loss in the weight of the steers, upon daily weighing at the end in both the tests, indicate that possibly the greatest gains cannot be secured with range grown steers if weighed frequently, because of the excitement occasioned in handling the animals.

Table VII.—Weights and Gains by Periods of Four Weeks

STEERS 1901-2

		Lot 1		Lot 2		Lot 3	
Date	No. days fed	Weight pounds	Gain pounds	Weight pounds	Gain pounds	Weight pounds	Gain pounds
Oct. 12, 1901	00	1920		1942		1920	
Nov. 9, 1901	28	2120	200	2180	238	2020	100
Dec. 7, 1901	56	2264	144	2230	50	2116	96
Jan. 4, 1902	84	2280	16	2296	66	2108	—8
Feb. 1, 1902	112	2422	142	2492	196	2306	198
Mar. 1, 1902	140	2558	136	2620	128	2400	94
Mar. 29, 1902	168	2602	44	2644	24	2482	82

Table VIII.—Live and Dressed Weight and per cent. of Dressed Weight

STEERS 1901-2

Steer No.	Live weight Pounds	Dressed weight Pounds	Per cent. of dressed weight Pounds
Lot 1.—Alfalfa			
1	1046	562	53.72
2	840	446	53.09
3	762	402	52.75
Total..........	2648	1410	
Average per head..	**882⅔**	**470**	**53.24**
Lot 2.—Alfalfa and Kafir-corn Stover			
4	1110	584	52.61
5	776	406	52.31
6	800	410	51.25
Total..........	2686	1400	
Average per head..	**895⅓**	**466⅔**	**52.12**
Lot 3.—Alfalfa and Corn Stover			
7	835	430	51.49
8	854	422	49.41
9	884	468	52.94
Total..........	2573	1320	
Average per head..	**857⅓**	**440**	**51.30**

EXPERIMENT WITH LAMBS

1901-2

DESCRIPTION OF LAMBS

The experiment with lambs was made with thirty head purchased from Mr. H. Merten, of Hatch, New Mexico. They were selected from the spring crop. They were grades with a mixture of merino blood which showed strongly in several individuals. They were of a fair feeding type and a good strong lot. Medium sized lambs were selected and they averaged about 45 pounds each.

During the ten days following the purchase the whole herd of lambs was allowed to drift southward covering about half of the distance. They were then separated and driven to Mesilla Park a distance of about 22 miles, arriving in good condition although the roads were very heavy, it having rained a good portion of the time. The second day after arrival, Nevember 2nd, the lambs were put into the feeding pens and the test was begun.

PRICE PAID AND RECEIVED

The lambs cost $1.55 per head delivered about one-half the distance. No account was taken of the expense of delivering them the balance of the way for the reason that a larger number would have been delivered the whole distance without extra expense. A carload of such lambs could have been purchased at $1.35 per head, it is believed, which would have made the results a little better.

At the end of the test all of the lots were in excellent condition for the local markets. They were sold in El Paso, Texas, at five cents per pound on foot, the weights being taken upon arrival without giving either food or water. They were conveyed to El Paso, a distance of about forty miles, in wagons and were on the road thirteen hours, including the stop at noon of about one hour. The thirty lambs made two light loads of a little more than 1,000 pounds each. In the financial statement the cost of delivering is figured on car lots by freight since it is not likely that a less number would be fed at one time. The expense of hauling in wagons is not unreasonable when a light load of grain or other supplies is brought back on the return trip.

DIVISION

The lambs were divided into three lots of ten lambs each as nearly equal in weight and quality as it was possible to divide them. Each lot was weighed once a week at 2 o'clook p. m.

In order to be able to distinguish the lambs, should they break out and become mixed together, they were marked with black spots upon the wool.

FEEDS

The source of the feeds for the lambs was the same as for the steers fed during the same winter, except that one lot of lambs received a corn ration in addition to the other feeds. The corn fed was a mixture of dent and flint varieties, but largely of the former. Most of the corn was purchased from native farmers at $1.50 per fanega. One fanega is equal to 150 pounds, therefore, the corn cost $1.00 per 100 pounds. Salt was kept by the lambs.

Lot 1 received alfalfa hay alone.

Lot 2 received alfalfa hay, shreded kafir-corn stover, shreded corn stover and corn.

Lot 3 received the same ration as lot 2 except that it received no corn.

Each lot was given all they would eat of hay and stover. Lot 2 was started on a very small amount of corn after they had become accustomed to the alfalfa. The corn ration was very gradually increased to all they would take and clean up.

The lambs were never off feed and there was very little scouring. At one time three lambs of lot 2, when the corn ration was pushed to its highest point, scoured a little but the amount of corn fed was reduced at once and no bad results seemed to follow. Mr. J. W. Bouts, who was in charge of the feeding, deserves commendation for his skillful management of the lambs.

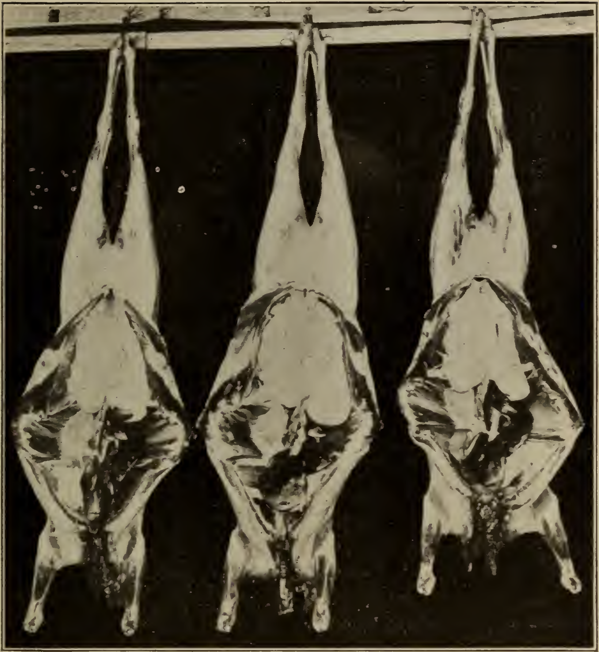
THE FEEDING PERIOD

The test was begun on November 2nd, 1901, and continued for 128 days, closing March 9th, 1902. The lambs were in good enough condition to have been sold at an earlier date but the weighing records showed that they were making excellent gains, and as the market was becoming stronger they were held somewhat longer than was absolutely necessary. Plates Nos. I and II represent one lamb from each lot when they were slaughtered.

MARKETS

The demand for fat lambs is somewhat more brisk than it is for fat steers. It requires more skill and care in feeding sheep than is required for steer feeding which fact tends to make sheep feeding with many less desirable, but the feeder should bear in mind that rapid gains, quick returns and good prices are usually obtainable for lambs and sheep.

Plate I



Lot 3
Lamb fed on
alfalfa,
kafir-corn stover
and corn stover

Lot 2
Lamb fed on
alfalfa,
kafir-corn stover,
corn stover and
corn

Lot 1
Lamb fed on
alfalfa

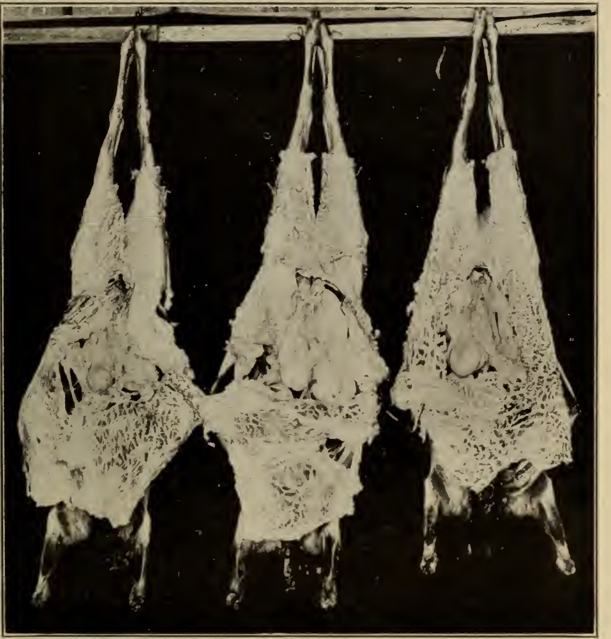
Table IX.—Financial Statement

LAMBS 1901-2

Showing the profit on each lot with alfalfa hay figured as follows: at the market price on board car, at cost on board car and at cost in the stack on the farm.

		Alfalfa hay, baled, at $7.00 per ton. Kafir-corn Stover and Corn Stover, shredded, at $4.00 per ton.		Alfalfa hay, baled, at $3.50 per ton. Kafir-corn Stover and Corn Stover, shredded, at $4.00 per ton.		Alfalfa hay, in stack, at $2.50 per ton, Kafir-corn Stover and Corn Stover, shredded, at $4.00 per ton.	
		Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Lot 1	By 10 lambs, 656.25 pounds live weight at 5c......		$32.81		$32.81		$32.81
	To 10 lambs at $1.55 per head	$15.50		$15.50		$15.50	
	To 2811 pounds alfalfa hay	9.84		4.92		3.51	
	To loading and freight...	.60	25.94	.60	21.02	.60	19.61
	Profit.......	....	**$6.87**	....	**$11.79**	....	**$13.20**
Lot 2	By 10 lambs, 722 pounds live weight at 5c....		$36.10		$36.10		$36.10
	To 10 lambs at $1.55 per head........	$15.50		$15.50		$15.50	
	To 1240 pounds alfalfa hay	4.34		2.17		1.55	
	To 450 pounds kafir-corn and corn stover.......	.90		.90		.90	
	To 1053.5 pounds corn at $20.00 per ton........	10.53		10.53		10.53	
	To loading and freight...	.60	31.87	.60	29.70	.60	29.08
	Profit.....	....	**$4.23**	....	**$6.40**	....	**$7.02**
Lot 3	By 10 lambs, 583.33 pounds live weight at 5c......		$29.17		$29.17		$29.17
	To 10 lambs at $1.55 per head......	$15.50		$15.50		$15.50	
	To 1954 pounds alfalfa hay	6.84		3.42		2.44	
	To 578 pounds kafir-corn and corn stover..... ..	1.15		1.15		1.15	
	To loading and freight...	.60	24.09	.60	20.67	.60	19.69
	Profit.......	....	**$5.08**	....	**$8.50**	....	**$9.48**

Plate II



Lot 3	Lot 2	Lot 1
Lamb fed on alfalfa, kafir-corn stover and corn stover	Lamb fed on alfalfa, kafir-corn stover, corn stover and corn	Lamb fed on alfalfa

Table X.—Feeds Consumed

LAMBS 1901-2

	Lot 1 Pounds	Lot 2 Pounds	Lot 3 Pounds
Total alfalfa hay	2811.	1240.	1954.
Total kafir-corn and corn stover	....	450.	578.
Total corn	....	1053.5	....
Total feed	2811.	2743.5	2532.
Average daily roughage per head (128 days)	2.2	1.32	1.98
Average roughage per head per month (30 days)	66.	39.6	59.4
Nutritive ratio	1:3.8	1:6.5	1:4.6

Table XI.—Weights and Gains

LAMBS 1901-2

	Lot 1	Lot 2	Lot 3
Weight at beginning of test	450.	458.	450.
Weight at end of test	687.3	757.3	634.6
Total gain	237.3	299.3	184.6
Average gain per head	23.73	29.93	18.46
Average daily gain per head (128 days)	.185	.233	.144
Average daily gain per 1000 pounds live weight	4.12	5.10	3.20
Pounds food to make 1 pound gain	11.845	9.166	13.716
Pounds food to make 100 pounds gain	1184.5	916.6	1371.6
Cost of 1 pound gain*	$ .0415	$ .0527	$ .0433
Cost of 100 pounds gain	$4.15	$5.27	$4.33

* Alfalfa hay, baled, $7.00 per ton, kafir-corn and corn stover, shredded, estimated at $4.00 per ton.

Table XI, giving the weights and gains for the lambs fed, brings out the interesting point that all of the lots returned not only a total net profit on the feed consumed but also made the gains at a profit, with the exception of lot 2; that is, the gains were made for less than five cents per pound, the price received for the lambs. A further study of the table shows that for every 1000 pounds live weight at the beginning of the test the average daily gain for the different lots was as follows: Lot 1, 4.12 pounds, lot 2, 5.11 pounds and lot 3, 3.30

pounds. Lot 1, which received alfalfa hay alone made the cheapest gains; lot 3, which had stover in addition to the hay stands next in cost of gain; and lot 2, which had a corn ration made the costliest gains of all. The high price of the corn probably was the cause of the comparatively high cost of the gains.

Table XII.—Comparison by lots between the rations composed of Alfalfa; Alfalfa, Kafir-corn Stover, Corn Stover and Corn; and Alfalfa, Kafir-corn Stover and Corn Stover.

LAMBS 1901-2

	Lot 1 Alfalfa	Lot No. 2 Alfalfa, Kafir-corn Stover, Corn Stover and Corn	Lot No. 3 Alfalfa, Kafir-corn Stover and Corn Stover
Total pounds gained	237.3	299.3	184.6
Average gain per head	23.73	29.93	18.46
Average daily gain per head (128 days)	.185	.233	.144
Average daily gain per 1000 pounds live weight	4.12	5.10	3.20
Pounds roughage to make 100 pounds gain	1184.5	564.6	1371.6
Pounds roughage to make 1 pound gain	11.845	5.646	13.716
Pounds food to make 100 pounds gain	1184.5	916.6	1371.6
Pounds food to make 1 pound gain	11.845	9.166	13.716
Cost of 100 pounds gain (*alfalfa hay at $7.00 per ton)	$ 4.15	$ 5.27	$ 4.33
Cost of 100 pounds gain (*alfalfa hay at $3.50 per ton)	2.07	4.54	2.48
Cost of 100 pounds gain (*alfalfa hay at $2.50 per ton)	1.48	4.34	1.94
Return per ton for alfalfa hay	11.89	13.82	11.92
Return per acre for alfalfa hay **	35.67	41.46	35.76
Selling price per head	3.22	3.55	2.86
Cost of lambs per head	1.55	1.55	1.55
Cost of food per head (*alfalfa hay at $7.00 per ton)	.98	1.58	.80
Profit per head (*alfalfa hay at $7.00 per ton)	.69	.42	.51
Cost of food per head (*alfalfa hay at $3.50 per ton)	$ .49	$ 1.36	$ .46
Profit per head (*alfalfa hay at $3.50 per ton)	1.18	.64	.85
Cost of food per head (*alfalfa hay at $2.50 per ton)	.35	1.30	.36
Profit per head (*alfalfa hay at $2.50 per ton)	1.32	.70	.95
Average per cent. of dressed weight	48.28	54.31	47.34

* Shredded kafir-corn and corn stover, estimated at $4.00 per ton.
** Reckoned at an average yield of three tons per acre per year.

Table XIII.—Return per Ton for Alfalfa Hay

LAMBS 1901-2

Lot 1

By 10 lambs. 656.25 pounds at 5c		$32.81
To 10 lambs at $1.55 per head	$15.50	
To loading and freight	.60	16.10
Balance to the credit of alfalfa hay		$16.71
Recived for alfalfa hay per ton		**$11.89**

Lot 2

By 10 lambs, 722 pounds at 5c		$36.10
To 10 lambs at $1.55 per head	$15.50	
To 450 pounds corn and kafir-corn stover at $4.00 per ton	.90	
To 1053.5 pounds corn at $20.00 per ton	10.53	
To loading and freight	.60	27.53
Balance to the credit of alfalfa hay		$8.57
Received for alfalfa hay per ton		**$13.82**

Lot 3

By 10 lambs, 583.33 pounds at 5c		$29.17
To 10 lamb at $1.55 per head	$15.50	
To 578 pounds kafir-corn stover at $4.00 per ton	1.15	
To loading and freight	.60	17.25
Balance to the credit of alfalfa hay		$11.92
Received for alfalfa hay per ton		**$12.20**

Table XIV.—Weights and Gains by Periods of One Week

LAMBS 1901-2

Date	Lot 1		Lot 2		Lot 3	
	Weight pounds	Gain pounds	Weight pounds	Gain pounds	Weight pounds	Gain pounds
Nov. 2, 1901.....	450		458		450	
Nov. 9, "	470	20	468	10	446	—4
Nov. 16, "	498	28	500	32	460	14
Nov 23, "	490	—8	500	00	470	10
Nov. 30, "	498	8	512	12	468	—2
Dec. 7, "	522	24	534	22	488	20
Dec. 14, "	516	—6	520	—14	476	—12
Dec. 21, "	528	12	548	28	488	12
Dec. 28, "	534	6	564	16	488	00
Jan. 4, 1902.....	546	12	580	16	502	14
Jan. 11, "	564	18	594	14	514	12
Jan. 18, "	560	—4	610	16	516	2
Jan 25, "	582	22	620	10	522	6
Feb. 1, "	604	22	646	26	554	32
Feb. 8, "	625	21	675	29	570	16
Feb. 15, "	636	11	700	25	590	20
Feb. 22, "	664	28	714	14	600	10
Mar. 1, "	668	4	740	26	610	10
Mar. 3, "	676	8	744	4	624	14
Mar. 4, "	674	—2	746	2	624	00
Mar. 5, "	680	6	750	4	626	2
Mar. 6, "	682	2	744	—6	626	00
Mar. 8, "	690	8	762	18	638	12
Mar. 9, "	690	0	766	4	640	2

Table XV.—Weights and Gains by Periods of Four Weeks

LAMBS 1901-2

		Lot 1		Lot 2		Lot 3	
Date	No. days fed	Weight pounds	Gain pounds	Weight pounds	Gain pounds	Weight pounds	Gain pounds
Nov. 2, 1901	00	450		458		450	
Nov. 30, 1901	28	498	48	512	54	468	18
Dec. 28, 1901	56	534	36	564	52	488	20
Jan. 25, 1902	84	582	48	620	56	522	34
Feb. 22, 1902	112	664	82	714	94	600	78

EXPERIMENT WITH STEERS

1902–3

DESCRIPTION OF STEERS

The steers for the experiment of the winter of 1902–3, thirty-two head, were purchased from Mr. Charles Gatlin, of Magdalena, New Mexico. They were from a herd of about 800 head that had been transferred from Magdalena to a range near Rincon about two weeks previous to the purchase. The steers were long yearlings and while they had fairly good frames yet they were quite thin in flesh. Except for this fact they would have been a representative lot of range steers. Plates Nos. III, IV, V and VI represent the steers at the time the corn ration was begun March 1st, and when the test ended on April 6th, 1903. The steers were dehorned and marked so that they could be distinguished should they become mixed.

PRICE PAID AND RECEIVED

Sixteen dollars per head was paid for the steers delivered at the Station farm. This was probably a little more than a larger number would have cost.

The alfalfa hay ran out before the steers were all well finished and the high price of hay at the time precluded the purchase of more for continuing the test. The steers were sold in Las Cruces for seven cents per pound dressed weight. If they had been held longer there is little doubt but that they would have brought a better price for two reasons: all of them would have been well finished and they could have been marketed at a season when good range butcher-stuff is always scarce.

DIVISION

The steers were divided into four lots of eight steers each as nearly equal in weight and quality as it was possible to divide them. It was the intention to weigh the lots once each week and also to weigh the individual steers but they were so wild that frequent weighing was abandoned. The weights were made at 10 o'clock a. m.

FEEDS

The steers were started on good grama hay and very gradually transferred to alfalfa hay. The alfalfa hay was all first-class. The corn fed was white No. 3 or better, purchased from Bossemeyer Bros., Superior, Nebraska. The wheat was grown on the Station farm, and the bran was purchased at a local mill. The corn cost $1.25 per 100 pounds f. o. b. Mesilla Park and 50c per ton, or 2½c. per 100 pounds, was allowed for delivering it from the depot to the Station farm,—a distance of about one-half mile. The wheat and bran were figured at $1.00 per 100 pounds, the price paid for the bran and the price at which wheat at the beginning of the milling season is sold. Both the corn and wheat were cracked. Salt was provided for the steers.

Lot 1 received alfalfa hay and about one-third of a full ration of corn.

Lot 2 received alfalfa hay and a full ration of corn.

Lot 3 received alfalfa hay and about one-third of a full ration of a mixture of wheat and bran in the proportion of three parts of wheat to one part of bran by weight.

Lot 4 received alfalfa hay alone.

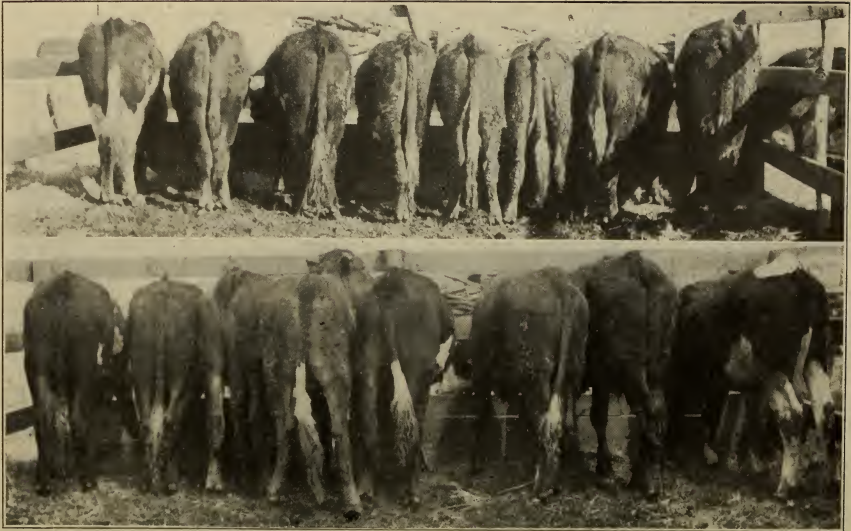
The lots that received grain were started on a small quantity, the amount being very gradually increased until the desired amount was given.

THE FEEDING PERIOD

The feeding was begun on December 17th, 1902. The lots all received the same ration, alfalfa hay, until the close of February 1903,—a period of 76 days. This gave an opportunity to make a comparison between the lots which were later to receive different rations. The grain ration was begun on March 1st, 1903 and continued until the experiment was closed on April 6th. The total length of the feeding period was 111 days but the period for feeding grain was so short, for reasons already given, that lot 2 scarcely got on full feed when the test was stopped. The total feeding period was long enough to fit lots 1, 2 and 3 for the local markets, but it was too short in which to fit lot 4 which had only a ration of alfalfa hay. Furthermore, the butcher objected to the meat from lot 4 but made no complaint against that from the other lots.

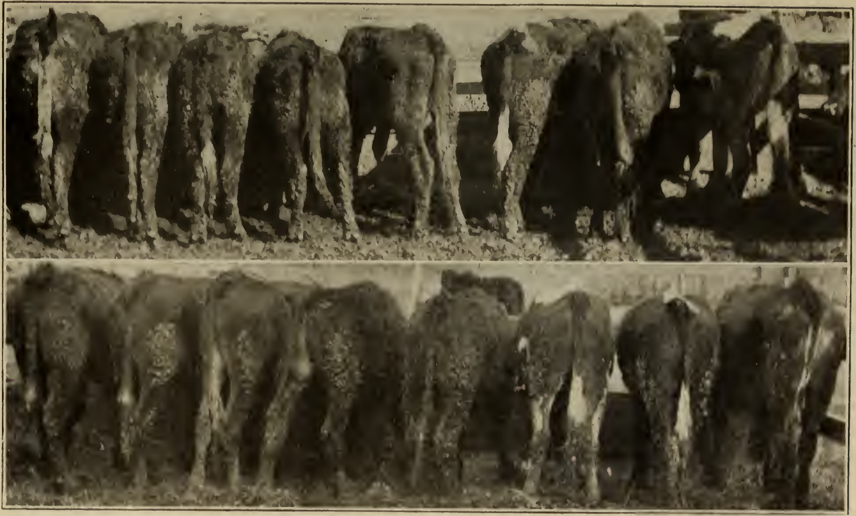
The steers had to learn to eat grain. Most of them gave little or no trouble. Three steers in lot 1, however, refused to eat corn until near the end of the test. While the result obtained from lot 1 are presented in tabular form, no attempt has been made to draw conclusions therefrom.

Plate III



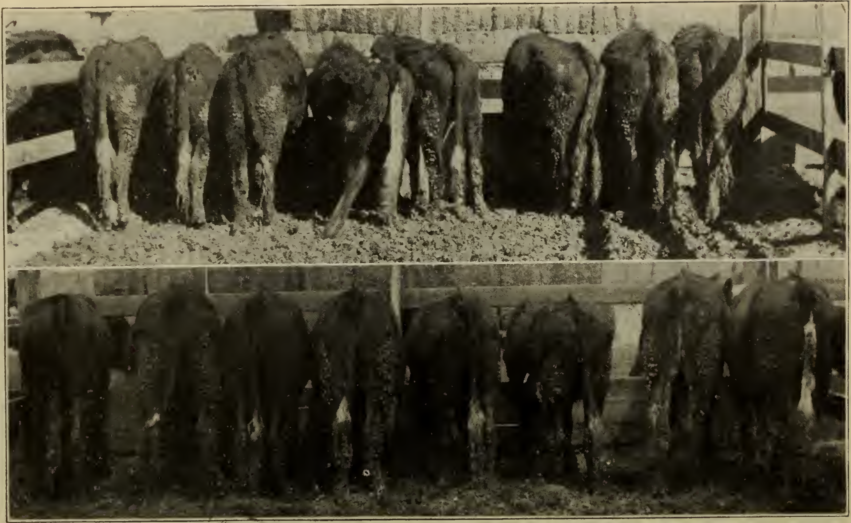
The upper figure represents Lot 1 when grain feeding was begun.
The lower figure represents Lot 1 at the end of the test.

Plate IV



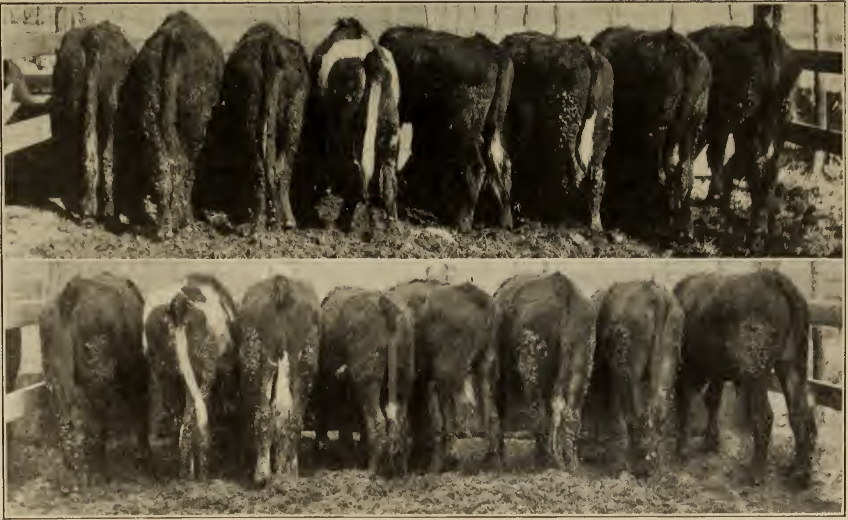
The upper figure represents Lot 2 when grain feeding was begun.
The lower figure represents Lot 2 at the end of the test.

Plate V



The upper figure represents Lot 3 when grain feeding was begun.
The lower figure represents Lot 3 at the end of the test.

Plate VI



The upper figure represents Lot 4 when grain feeding was begun with Lots 1, 2 and 3.
The lower figure represents Lot 4 at the end of the test.

Table XVI.—Financial Statement

STEERS 1902-3

Showing the profit or loss on each lot with alfalfa hay figured as follows: at the market price on board car, at cost on board car and at cost in the stack on the farm.

		†Alfalfa and grama hay, baled, at $7.00 per ton.		Alfalfa and grama hay, baled, at 3.50 per ton.		Alfalfa and grama hay, in stack, at $2.50 per ton.	
		Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Lot 1	By 8 steers, 2824.17 pounds dressed weight at 7c...		$197.69		$197.69		$197.69
	To 8 steers at $16.00 per head...	$128.00		$128.00		$128.00	
	To 14660.5 pounds alfalfa hay...	51.31		25.66		18.33	
	To 1870.5 pounds grama hay...	6.55		3.27		2.34	
	To 1047 pounds corn at $25.50 per ton...	13.35	199.21	13.35	170.28	13.35	162.02
	Profit or loss...		**$1.52***		**$27.41**		**$35.67**
Lot 2	By 8 steers, 3004.5 pounds dressed weight at 7c..		$210.32		$210.32		$210.32
	To 8 steers at $16.00 per head...	$128.00		$128.00		$128.00	
	To 14496 pounds alfalfa hay...	50.74		25.37		18.12	
	To 1622 pounds grama hay...	5.67		2.84		2.03	
	To 1518 pounds corn at $25.50 per ton...	19.35	203.76	19.35	175.56	19.35	167.50
	Profit...		**$6.56**		**$34.76**		**$42.82**
Lot 3	By 8 steers, 2976.8 pounds dressed weight at 7c..		$208.38		$208.38		$208.38
	To 8 steers at $16,00 per head...	$128.00		$128.00		$128.00	
	To 14796 pounds alfalfa hay...	51.79		25.89		18.50	
	To 1580 pounds grama hay...	5.53		2.77		1.97	
	To 1002 pounds wheat and bran at $1.00 per 100 bs.	10.02	195.34	10.02	166.68	10.02	158.49
	Profit...		**$15.04**		**$41.70**		**$49.89**
Lot 4	By 8 steers, 2856.7 pounds dressed weight at 7c.		$199.97		$199.97		$199.97
	To 8 steers at $16.00 per head...	$128.00		$128.00		$128.00	
	To 15340 pounds alfalfa hay...	53.69		26.84		19.17	
	To 1719.5 pounds grama hay...	6.02	187.71	3.01	157.85	2.15	149.32
	Profit...		**$12.26**		**$42.12**		**$50.65**

†Grama hay is reckoned at the same price as alfalfa though it is not equal to alfalfa in feeding value.

*Loss.

Table XVII.—Weights and Gains

STEERS 1902-3

	Lot 1	Lot 2	Lot 3	Lot 4
Weight at beginning of test	4450.	4350.	4344.	4322.
Weight at end of test	5530.	5774.6	5781.3	5710.
Total gain	1080.	1424.6	1437.3	1388.
Average gain per head	135.	178.	179.6	173.5
Average daily gain per head (111 days)	1.22	1.60	1.62	1.56
Average daily gain per 1000 pounds live weight.	2.186	2.950	2.981	2.893
Pounds food to make 1 pound gain	16.27	12.38	12.09	12.29
Pounds food to make 100 pounds gain	1627.	1238.	1209.	1229.
Cost of 1 pound gain (alfalfa hay at $7.00 per ton)	$ .0659	$ .0532	$ .0468	$ .0430
Cost of 100 pounds gain (alfalfa hay at $7 00 per ton)	6.59	5.32	4.68	4.30

Table XVIII.—Comparison Between Lots by Periods

Showing the pounds of food consumed, pounds of food to make one pound gain, cost of one pound gain, average daily rougnage per head, average daily food per head and nutritive ratio.

STEERS 1902-3

	1st Period				2nd Period				1st and 2nd Periods			
	Lot 1	Lot 2	Lot 3	Lot 4	Lot 1	Lot 2	Lot 3	Lot 4	Lot 1	Lot 2	Lot 3	Lot 4
Alfalfa hay fed	9063.	9069.	9217.	9094.	5597.5	5427.	5579.	6246.	14660.5	14496.	14796.	15340.
Grama hay fed	1870.5	1622.	1580.	1719.5	......	......	......	......	1870.5	1622.	1580.	1719.5
Grain fed	......	......	......	......	1047.	1581.	1002.	......	1047.	1518.	1002.	......
Gain	626.	697.	782.	814.	454.	727.6	655.3	574.	1080.	1424.6	1437.3	1388.
Pounds food to make 1 pound gain	17.46	15.34	13.81	13.28	14.63	9.55	10.04	10.88	16.27	12.38	12.09	12.29
Cost of 1 pound gain*	$.061	$.054	$.048	$.046	$.073	$.053	$.045	$.038	$.066	$.053	$.047	$.043
Average daily roughage per head	18.47	18.06	18.24	18.27	18.91	18.33	18.84	21.10	18.61	18.15	18.44	19.21
Average daily food per head	18 47	18.06	18.24	18.27	22.44	23.46	22.23	21.10	19.79	19.86	19.57	19.21
Nutritive ratio					1:4.5	1:4.8	1:4.3	1:3.8				

* Alfalfa hay at $7.00 per ton.

Table XIX.—Comparison between Lot 1, fed on alfaifa hay and a light ration of corn; Lot 2, fed on alfalfa hay and a heavy ration of corn; Lot 3, fed on alfalfa hay and a light ration composed of wheat and bran in the proportion of three parts wheat to one part bran by weight; and Lot 4, fed on alfalfa hay alone.

STEERS 1902-3

	Lot 1	Lot 2	Lot 3	Lot 4
	Alfalfa hay and a light ration of corn	Alfalfa hay and a heavy ration of corn	Alfalfa hay and a light ration of wheat & bran	Alfalfa hay alone
Total pounds gained	1080.	1424.6	1437.3	1388.
Average gain per head	135.	178.	179.	173.5
Average daily gain per head (111 days)	1.22	1.60	1.62	1.56
Average daily gain per 1000 pounds live weight	2.186	2.950	2.981	2.893
Pounds roughage to make 100 pounds gain	1530.	1131.	1139.	1229.
Pounds roughage to make 1 pound gain	15.30	11.31	11.39	12.29
Pounds food to make 100 pounds gain	1627.	1238.	1209.	1229.
Pounds food to make 1 pound gain	16.27	12.38	12.09	12.29
Cost of 100 pounds gain (alfalfa hay at $7.00 per ton)	$ 6.59	$ 5.32	$ 4.68	$ 4.30
Cost of 100 pounds gain (alfalfa hay at $3.50 per ton)	3.91	3.34	2.69	2.15
Cost of 100 pounds gain (alfalfa hay at $2.50 per ton)	3.15	2.77	2.12	1.54
Return per ton for alfalfa hay **	6.82	7.81	8.59	8.44
Return per acre for alfalfa hay §	20.46	23.43	25.77	25.32
Cost of steers per head	16.00	16.00	16.00	16.00
Selling price per head	24.71	26.29	26.05	24.99
Cost of food per head (alfalfa hay at $7.00 per ton)	8.90	9.47	8.42	7.46
Profit per head (alfalfa hay at $7.00 per ton)	.19*	.82	1.63	1.53
Cost of food per head (alfalfa hay at $3.50 per ton)	5.29	5.95	4.84	3.73
Profit per head (alfalfa hay at $3 50 per ton)	3.43	4.35	5.21	5.27
Cost of food per head (alfalfa hay at $2.50, per ton)	4.25	4.94	3.81	2.67
Profit per head (alfalfa hay at $2.50 per ton)	4.46	5 35	6.24	6.33
Average per cent. of dressed weight	51.07	52.03	51.49	50.03

*Loss.

**Grama reckoned at the same price as alfalfa hay.

§Reckoned at an average yield of three tons per acre per year.

Table XIX shows that the gains made by lots 2 and 3 were about equal although lot 2 received the heaviest ration of grain. Why this was so we are unable at the present time to tell. It is safe to say, at least, that alfalfa hay, wheat and bran form a good ration, and since these feeds, as a rule, are somewhat cheaper than corn they may safely form a large part of any fattening ration. Corn fed meat is considered superior to the wheat fed product but for local market demands wheat and bran will prove quite satisfactory as a feed.

Lot 4, that received only alfalfa hay, made the cheapest gains of the four lots. It does not follow from this that it is always best to feed alfalfa hay alone as a careful study of Tables V, XIII and XX will show. With only one exception (as stated before no comparison is made with lot 1) which may perhaps be accounted for by the short feeding period, the return per ton for the alfalfa hay is greater when grain is fed with the alfalfa than when the alfalfa is fed alone. Furthermore, the hay fed meat is inferior to the corn fed product.

If these results are confirmed by future experiments, they will be of considerable value to the feeder, and of special interest to growers of alfalfa since by feeding a grain ration, though comparatively high in price, with the alfalfa hay the hay will bring more per ton than when fed without grain.

Table XX.—Return per Ton for Alfalfa Hay

STEERS 1902-3

Lot 1		
By 8 steers, 2824.17 pounds dressed weight at 7c		$197.69
To 8 steers at $16.00 per head	$128.00	
To 1047 pounds corn at $25.50 per ton	13.35	141.35
Balance to the credit of alfalfa hay		$ 56.34
Received for alfalfa hay per ton*		**$ 6.82**
Lot 2		
By 8 steers, 3004.59 pounds dressed weight at 7c		$210.32
To 8 steers at $16.00 per head	$128.00	
To 1518 pounds corn at $25.50 per ton	19.35	147.35
Balance to the credit of alfalfa hay		$ 62.97
Received for alfalfa hay per ton*		**$ 7.81**
Lot 3		
By 8 steers, 2976.8 pounds dressed weight at 7c		$208.38
To 8 steers at $16.00 per head	$128.00	
To 250½ pounds bran at $20.00 per ton	2.505	
To 751½ pounds wheat at $20.00 per ton	7.515	$138.02
Balance to the credit of alfalfa hay		$ 70.36
Received for alfalfa hay per ton*		**8.59**
Lot 4		
By 8 steers, 2856.71 pounds dressed weight at 7c		$199.97
To 8 steers at $16.09 per head	$128.00	$128.00
Balance to the credit of alfalfa hay		$ 71.97
Received for alfalfa hay per ton*		**$ 8.44**

*Grama reckoned at the same price as alfalfa.

Table XXI.—Live and Dressed Weight and per cent. of Dressed Weight

STEERS 1902-3

Lot 1				Lot 3			
Steer No.	Live weight	Dressed weight	Per cent. dressed weight	Steer No.	Live weight	Dressed weight	Per cent. dressed weight
1	650	322	49.53	1	838	412	49.16
2	684	338	49.41	2	774	394	50.90
3	732	372	50.82	3	770	390	50.65
4	590	320	54.23	4	710	356	50.14
5	794	410	51.63	5	692	353	51.01
6	...	370	.....	6	752	415	55.18
7	...	365½	.....	7	640	346	54.06
8	...	385½	.....	8	724	372	51.38
Total....	....	2873		Total....	5900	3038	
Average	**690**	**352**	**51.07**	Average	**737.5**	**379.7**	**51.49**
Lot 2				Lot 4			
1	802	410	51.12	1	558	270	48.38
2	650	340	52.30	2	628	272	43.31
3	806	400	49.62	3	836	434	51.91
4	762	380	49.86	4	800	430	53.75
5	774	400	51.67	5	796	410	51.50
6	734	416	56.67	6	766	380	49.60
7	686	358	52.18	7	722	360	49.86
8	682	364	53.37	8	698	348	49.85
Total....	5896	3068	....	Total....	5804	2904	....
Average	**737**	**383.5**	**52.03**	Average	**725.5**	**363**	**50.03**

Practically all of the cattle disposed of on the local markets are sold without weighing at so much per head. This method affords little opportunity to determine the per cent. of dressed weight of the different classes. Table XXI gives the live weight, the dressed weight and the per cent. of dressed weight at the time each steer was slaughtered. The average per cent. of dressed weight is figured on the total weight of each lot except lot 1, which was figured on the first five steers. This was necessary because a caving well near the scales rendered their use unsafe.

It will be seen that the average dressed weight increased with the amount of grain fed. Lot 4, which had no grain dressed 50.03 per cent.; lot 3, which had a light grain ration dressed 51.49 per cent.; and lot 2, which received a fairly heavy grain ration dressed 52.03 per cent. on the average.

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BULLETIN NO. 51

MAY 1904

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

NATIVE ORNAMENTAL PLANTS
OF
NEW MEXICO

BY

E. O. WOOTON

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The Bulletins of this Station will be mailed free to Citizens of New Mexico and to others as far as the editions printed will allow on application to the director

SUMMARY

1. Introduction suggesting the desirability of planting all kinds of shrubbery to increase the value of the property, for protection, for comfort, privacy, and beauty.

2. Recommending the use of native plants, because they are adapted to our dry soil, dry air, wind, hot days and cold nights, late spring frosts, and intense light.

3. Conditions in the valleys reviewed, with recommendations concerning windbreaks and other protective planting.

4. The conditions surrounding the average stockman's home, with suggestions for its improvement.

5. Notes on methods of obtaining such material.

6. Notes on the particular species of native plants which are of value as ornamentals.
    a. Coniferous trees.
    b. Deciduous trees.
    c. Shrubs.
    d. Vines.
    e. Herbaceous annuals and perennials.

7. Index of species.

INTRODUCTION

Bulletin Number 47* of this Station calls attention to the causes tending to produce instability in our population and hence lack of decorative adorment of the homes in our Territory. There is not the least doubt that these conditions were in existence in the past and that the resulting bad habits still affect our population. But the necessity for semi-nomadic life no longer exists and, with new and better conditions, our population is becoming more permanently attached to our soil and the instinct of home decoration is beginning to be aroused. While the "money making" period of our development is certainly not past, it is to be hoped that the "home making" period has begun.

Little need be said in argument for the increase in beauty which will accrue to our homes if surrounded by well set shrubbery. Much might be said advocating such decoration because of the increased privacy which it affords, when properly arranged, and there can be but little doubt of the value of privacy to the average dweller in town or city.

Much additional comfort in the way of shade and protection from wind, dust, and heat may be obtained for the home by the judicious use of shrubbery. Nor will anyone contradict the statement that the well shaded house, surrounded by lawns adorned with clumps of shrubs and blossoming plants and its porches festooned by vines, will command a higher price than the same house in the same location without its setting of plants.

A farm whose fields are protected by windbreaks and shelter-belts (which will also furnish fence posts and wood) is more valuable than one without these adjuncts. A family, living in a home so protected and embowered and appreciating its surroundings, is sure to have better taste and better standards of living than one not so blest.

All of these arguments lead to the conclusion that it is a wise thing to surround any home with protecting and beautifying plants and flowers. And then the question arises:—What plants shall we use?

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* "Shade Trees and Other Ornamentals," by Fabián Garcia.

A PLEA FOR THE USE OF OUR NATIVE PLANTS

The conditions necessary for the growth of plants are (1) food upon which they can subsist, both in the soil and in the air; (2) moisture in proper quantity in soil and air; (3) a certain total amount of heat during the growing season, as well as a temperature that is neither too high nor too low; and (4) a favorable amount of light. Different regions upon the earth's surface differ greatly in respect to the degree in which they supply these conditions, and, as a consequence, different localities have native floras which resemble each other in about the same degree as the growing conditions of the localities themselves approximate each other.

The degree to which the growing conditions may be artificially controlled varies considerably. The chemical content, mechanical condition or texture, and moisture content of the soil in any locality may be controlled with comparative ease, if small areas only are to be considered. But the humidity of the atmosphere, the temperature limits, and the light intensity of any region out of doors can be modified but a very small amount.

In an area so large as that of our Territory, almost all kinds of soils may be found, but the best natural soils occur only in the higher mountains where they have been sheltered and enriched by heavy forests. Along the foothills and on the mesas the soil is apt to be more or less coarse and rocky, thus requiring a great deal of water to produce plant growth. Here it is usually free from an excess of the salts of potassium, sodium and calcium which form the dreaded "alkali." This, however, is not always true, since the presence of these salts is in a degree dependent upon the kind of rocks of which the adjacent mountains are composed, as well as to some extent, upon the general topography of the region. In the river valleys, where most of our towns are built, the soil is usually the silt of the river and is apt to be fine grained and poorly aerated, while the underlying stratum is nearly always sand. Alkali is also very apt to be present in greater or less quantity in such soils.

These generalizations as to the soils of the Territory only show their variable nature and make necessary a careful consideration of the particular soil, in which we wish to grow plants.

Our Territory is all of it relatively high above the sea, its lowest valleys being more than 3,500 feet above that level, while some of the mountains rise considerably above timber line. This elevation, when taken in connection with our geographic position, produces climatic conditions in atmospheric humidity, temperature variations and extremes, and a light intensity that are especially severe on all plant life except that which is particularly adapted to such conditions. The lack of moisture in the air is particularly hard upon plants that are accustomed to a humid atmosphere, since it increases the evaporation from their leaf surfaces to such a degree that they are able with great difficulty to get enough water from the ground to replace that lost by evaporation.

Temperature changes, both diurnal and annual, are extreme with us, because our altitude renders our atmosphere thin and the extreme dryness but accentuates this effect. Objects in direct sunlight are quickly heated to a high temperature, while as soon as the sun is gone, all temperatures drop suddenly and severely. Our growing season is very long and the total quantity of heat received during a season is very great, a fact tending to produce rapid growth and relatively short life in our trees.

Light is a necessity to all self-supporting plants (i. e. not parasitic or saprophytic); they must have light in order to manufacture their food. Very few people seem to appreciate this necessary condition of plant life. But plants must have light in the proper quantity, and this quantity differs fully as much as does the proper quantity of water which they require. Some species will grow only in strong light (i. e. are "light demanding" species) while others will endure only a small amount; still others are known as shade enduring species, they take little or much as the case may be. And among trees in particular, the young tree may be a shade enduring species while the mature tree may be light demanding. The light conditions, any place in New Mexico outside of the dense coniferous forests of the high mountains, are extremely severe; the direct sunlight is most intense and the reflected light is very strong.

When one takes all these conditions into consideration and remembers just how little they can be artificially modified in the open, the wonder is, not that so *few* of the plants commonly cultivated in the humid regions will grow here, but that so *many* of them are able to adapt themselves to such inhospitable surroundings and thrive.

Now our Territory has a covering of plants which are perfectly adapted to our climate and soil; scanty in places, it is true, but abundant and characteristically beautiful in others. Practically all of these plants are thoroughly adapted to those peculiarities of our climate which we can not control and which are so severe on the commonly cultivated ornamentals, viz: Very dry atmosphere, extreme daily variation in temperature, late spring frosts, very high summer temperature, and very intense light. Besides this some of them are inured to extreme dryness of soil and others will tolerate relatively large quantities of alkali.

It seems to me that probably the most important reason for wishing to cultivate the plants of the humid region in this Territory lies in the fact that we are almost all of us originally from that humid region and wish to reproduce, in the new home, conditions similar to those of the old. The desire is perfectly laudable; but does it not lead us away from our easiest method of ornamenting our homes and grounds? Does it not appear that our native plants are better adapted to the unalterable conditions of this region? Would it not be easier to supply artificially a good soil and a little extra water to plants from our mountains than to do the same thing for eastern plants and at the same time try to protect them from our sun, our frosts, our wind, and our dry atmosphere? Which procedure is the more likely to result favorably?

Then there are situations in which it is desirable to have some vegetation where only a limited supply of water is to be had at any time. In such locations some of the typical arid region plants would be thoroughly at home. While they may not be everything that is desirable, they are certainly much better than none, and no others are able to stand such a severe environment.

To me there is an appeal to "the eternal fitness of things" in our native vegetation. It seems at home, a part of the country, and as thoroughly appropriate and in place as an adobe house is in this sun-blest land of ours. This adaptation to environment is so marked in some of the trees and shrubs that, though flat-leaved and of deciduous ancestry, they are nevertheless evergreen and are thus rendered all the more valuable for ornamental purposes.

Hence I urge, as emphatically as may be, the use of our native plants; those plants which thrive in alkaline soil, which can stand six months of drouth, which do not sunscald and lose their stems and leaves on one side, which are rigid and strong enough to resist our winter and spring winds, and canny enough to keep from getting frost bitten when spring plays fast and loose with us. Give them a fair trial, study their natural adaptations, give them slightly better conditions than they naturally have, and I feel sure they will reward the thoughtful, careful gardener by growing even better than in their native habitats. In order to obtain this end, however, it will be necessary to appreciate the particular beauty of each and study *its* possible improvements. It will be impossible to make them over according to some preconceived ideas of beauty obtained elsewhere.

CONDITIONS IN THE VALLEYS

In our Territory there are three or four kinds of places where people make their homes. They build their houses in the open river valleys, either singly on the farms, or in groups, forming towns and cities; or they choose isolated situations near "water," on the mesas, or in the mountains, for the stockman's ranch. The mining camp is usually in some narrow cañon and is apt to be lacking in permanence.

In the valleys, whether on farms or in the towns, the conditions are more or less similar. Shelter is the thing most desired; shelter from the heat and the light of our summer sun, from the wind and dust, or from the public gaze. To these comforts should be added the pleasure and benefit which come from living in beautiful surroundings and striving to make them even more beautiful.

Most of the valley farm houses and not a few of the homes in the towns are more or less protected and beautified by the use of shrubs and trees. The value of fruit trees and grape vines is fully recognized, but I doubt if the simple money value alone of a proper use of shade trees, windbreaks, shelterbelts, shrubbery, and lawns is properly appreciated. Time spent in making the home more comfortable by protecting it, is not wasted, but is well invested. The hedge and shrubberry which keeps the dust out of the house more than pays for itself in saving floors and furniture, to say nothing of muscle and nervous energy spent in cleaning out the dirt. Bodily comfort counteracts nervous irritation and makes for general sweetness of disposition; and it should be our task to make the home the most comfortable place possible. For this reason alone, if for no other, properly and tastefully arranged shrubbery is one source of comfort and pleasure for the household.

There is no reason why practically any style of horticultural decoration may not be used about our irrigated farm and town houses. Formal gardens, informal planting, hedges, windbreaks, orchards and vineyards, vine covered arbors, summer houses and porches may all be had where water for irrigation is available.

Windbreaks and shelterbelts should be used much more in our cultivated valleys than is now the custom. There is little doubt that one of the worst enemies to our orchards and vineyards is our dry wind. Any means of protecting cultivated fields, orchards, vineyards, decorative shrubbery, and stock from the effect of these winds will be valuable to the valley farmer, and one of the most available forms of protection is to be found in the windbreak or shelterbelt of native trees.

THE RANCH HOUSE*

What is the average ranch house in New Mexico like? Think of those you know and judge whether each does not belong to one of the following types:

A "dobe" hut of one or two rooms, set out on a sun-blistered flat where bulls paw up clouds of pungent dust, while they bellow challenges at each other. Miles away through quivering air dance the distorted outlines of the cool timbered mountains.

A board shanty at the mouth of some cañon on the edge of a boulder strewn arroyo, with everything about it as inconveniently arranged as well can be.

A one-roomed log cabin with a "lean-to," in a beautiful mountain valley, but with every vestige of the native forest cut away from around the house for fifty or a hundred yards on all sides.

These are by no means the only kinds of ranch houses, but they are by far the commonest. Are these conditions necessary? It can hardly be claimed that they are satisfactory or desirable.

In the very nature of the case the great bulk of our Territory must ever be devoted to stock raising. Enough water falls within its limits to properly irrigate only a relatively small proportion of it, even if all that water were caught and hoarded and applied to irrigation. Such a thing being impossible, and the above statement being true of practically all the high arid region in which our Territory lies, we come back to our first proposition: i. e. the necessity of stock raising in the Territory. It is the only kind of agricultural work possible on the unirrigated lands.

---

* As used here the expression "ranch house" is intended to apply merely to the houses of stockmen which are not usually located in the irrigated valleys. The author understands that this is a restricted use of the expression which is not warranted by custom, but is here used for lack of a better term.

It is also recognized that, under the present system of handling stock, our Territory is losing a large part of the gain which might be ours if our land laws were so constructed as to give a stockman control of enough land to make a living on. But the law makers had other conditions in view when these laws were made, and as yet nothing has been suggested which will overcome the evil resulting to arid grazing lands.

The author also appreciates how this lack of control, the uncertainty of the returns for labor, the rough character of the work itself, the exposure it entails and irregularity of habits which it engenders, all tend to render the ranch house a mere "permanent camp," where one expects conveniences only a grade better than when on the "round up."

Again comes the question: Are these conditions necessary? The author thinks they are not, and fully believes that the day is not very distant when some of them will be materially improved by legislation favorable to the stockmen, which will give them a more assured "grip" on their ranges, and at the same time render labor less arduous, rough, and irregular, and make the ranch house still more "permanent" in character and less like a camp. Many ranches now possess sufficient permanence to make greater comfort a desideratum, but until the necessity for greater comfort is felt, no attempt to gain it will be made.

Some of the comforts which may be added to the ranch house (depending somewhat upon its location)are coolness and shade, protection from wind and dust, increased privacy, and added beauty, thus raising the mental standards and appreciation of its inmates. They may all of them be had at the cost of a little time and labor expended in the judicious transplanting of native plants which grow, in every case, not far from the ranch house.

The ranch on the mesa may be protected from dust and have its privacy and beauty materially increased by the use of the

Yuccas, sotols, ocotillo, and other shrubs of the mesa; while if a little water can be had, cottonwoods, ash, and soap-berry may be induced to add their shade, and cacti and many low plants will grow and bloom in such surroundings.

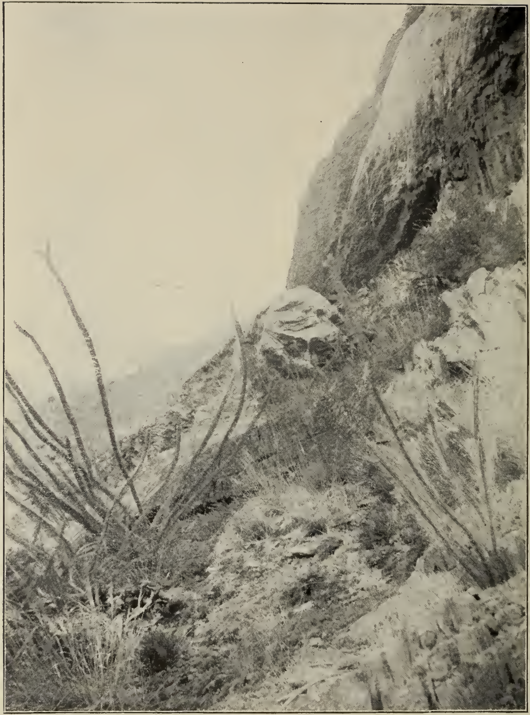
In the foothills, the site of the house can usually be selected, so as to take advantage of the shade and beauty of well grown trees. It is much easier to pipe the water some distance to the house in order that the house may be protected and beautified by trees already full grown, than it is to place the house near the water and wait for trees to grow. For the ranch located in the foothills or mountains there is an ever ready source of supply of trees and vines and shrubs to be found in the mountains near by, and the average stockman has abundance of time in which to transplant them.

There are, no doubt, good reasons why the tall, shallow-rooted conifers should be removed from close about the ranch house in the mountains, but the reasons which apply to the large trees certainly do not govern the placing of smaller trees like oaks and maples, and the use of vines and shrubs. Shade may not be so desirable, but beauty and privacy both are, and the care necessary to the production of a beautiful little mountain home has its effect upon the industry, taste, and neatness of the inhabitants.

It is hardly possible to say too much on the desirability of permanence in the population of our Territory. The ranchman who comes to stay is the desirable one. He works for the welfare of his township, his county, and his Territory; he is interested in its schools, its churches, its laws, and whenever a man is interested in a thing he does good work for it. He may not do the best thing in every case, but the general result of his energy makes for good in his region. The man who has invested muscle and time and thought and taste in trying to improve the conditions of his home will not be ready to abandon his results for a new place, and when once attached to a place, it is doubtful if any other man would do better in that place.

Showing Neglected Possibilities.

Possibilities Utilized.



Candlewood. Ocotillo.

The Usual Ranch on the Mesa.
Remedy: Yuccas, Cacti, Sotol, Etc.

METHOD OF HANDLING MATERIAL

It is not necessary to repeat here the instructions for transplanting dormant plants. Most people who have reached maturity have had some experience, and those who have not may find instructions in nearly any book on agriculture or horticulture, or even in some nurserymen's catalogues. Bulletins No. 40* and No. 47 of this Station give some details of this character which are particularly applicable to this region.

In this bulletin it has frequently been impossible to refer to a plant by anything except its Latin or scientific name because, so far as the author knows, it has no other. In speaking of the native plants that have no common names, popular descriptions have been given, so far as possible, and some illustrations have been inserted, but these methods will not always succeed in making the reader think of the plant referred to. Different common names are used for the same plant in different parts of the Territory and only a part of the plants here enumerated may be found in any one locality. These conditions will, no doubt, cause some confusion in using this bulletin. Many of the plants here described in their summer condition would be recognized in their dormant state only by a very careful observer. To avoid these difficulties, it is recommended that the would be gardener notice carefully the native plants of his region during the growing season, making particular note of the horticultural possibilities and habits of each, and at the same time examining each with sufficient care to be able to recognize it without leaves or flowers or fruit. When next they are dormant such plants as are selected may be transplanted. Such treatment is, of course, not necessary with any kind of evergreens.

It must be remembered that, *the roots of conifers must never be allowed to dry during the operation of transplanting.* A good way to avoid drying, is to "puddle" them at once, as nurserymen do, by dipping the roots into a thin mud or a mixture containing fresh cow manure and then wrapping them in wet straw or trash which will keep them moist.

---

* "A Southern New Mexico Flower Garden," by F. E. Lester.

Plants which grow in shallow rocky soil are rather difficult to dig because, in such soil, the roots spread widely, and in digging it is hard to avoid cutting off the smaller rootlets with the pick or spade. The moral to this is to get all the roots of the plant that you can.

Plants just transplanted must be watered immediately and the soil compacted sufficiently to bring the wet soil into close contact with the roots. Nor must the soil be allowed to cake and sun-crack later on, else the moisture will evaporate and the plants die. Practically nothing but cacti will bear transplanting into a dry soil without being irrigated at the time of transplanting, and I would irrigate cacti even if it were necessary to carry the water in a bucket.

NOTES ON THE NATIVE PLANTS

CONIFEROUS TREES

While there are a number of species of coniferous trees, or "evergreens" as they are quite frequently called, native in the Territory they are usually restricted to the higher altitudes. Only the **Juniper** *(Juniperus pachyphloea)*, the **Cedar** *(J. occidentalis)*, and the **Piñon** *(Pinus edulis)*, naturally grow at elevations below about 6,000 feet. The two junipers are very slow growers and are never very satisfactory trees, though their power of resisting drouth and heat would recommend them for exposed and dry localities. A single piñon, transplanted into this valley, as a small tree, thirty or more years ago, has made a symetrical tree about eighteen feet high. *Juniperus scopulorum* is a very graceful juniper which closely resembles the eastern "cedar" *(J. Virginiana)* and grows in our mountains at elevations of about 6,500 to 7,500 feet. Its slender branches are inclined to droop, its berries are small and covered with "bloom," its form is somewhat conical, and it is altogether a handsome tree. It would make a valuable decorative tree, of the rather formal sort, for lawns and door-yards in the cities which are at rather high elevations. The **Blue Spruce** *(Picea Parryana)* and the **White Spruce** *(Picea Engel-*

manni) should also be used in similar situations. They generally grow at slightly higher levels, but could, no doubt, be brought down from 500 to 1,000 feet below their natural levels by furnishing them with a small amount of shade and a little more water than naturally falls at such levels. The **Douglas Spruce** or **Oregon Fir** *(Pseudotsuga taxifolia)* and the **Bull Pine** *(Pinus ponderosa scopulorum)* would well repay the care necessary to getting them established. They make, relatively, rapid growth; the young trees ten or a dozen years old from the seed are generally ten to fifteen feet high. In the end they become majestic forest trees. One beautiful forest conifer is the **Balsam** or **White Fir** *(Abies concolor)*. It is particularly beautiful when young, and would, no doubt, grow in cultivation in cities which are as high above the sea level as Santa Fe or Las Vegas. In general it might be said that the native conifers grow too slowly and are too restricted as to the level at which they will grow to ever be very popular as shade or decorative trees in the Territory, and only those individuals who are anxious to make their surroundings resemble the natural forest conditions of the region will ever use them. The introduced species of Junipers, Arborvitae, and Cedrus* will be more popular, because of their more rapid growth and greater adaptability.

To all who would transplant conifers we would say: Be sure to transplant quite small trees.

DECIDUOUS TREES

Cottonwoods. Three distinct species of cottonwoods are native in the Territory and their use as shade trees is well nigh universal. As trees they have several points in their favor, and number most men among their friends, but occasionally one meets a man who says he would rather have no trees at all than have cottonwoods. His objections are usually matters of personal taste, though he is apt to talk of the dirt due to their "cotton" or the effect of the mistletoe. The first of these objections is easily avoided by planting the cuttings taken from the staminate* or so called "male" trees. The second difficulty necessitates the cutting out of the mistletoe about once a year; if properly watched the parasite never becomes very objectionable.

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*See Bull. No. 47, this Station, pp, 32, 36, 37, and 39.

The best feature of the cottonwoods is their very rapid growth. Five years of proper treatment will generally insure a good sized shade tree, and when once established they require very little attention. As an "all around" shade tree for the streets, roads, and drives there is probably nothing better growing in the Territory. Their symmetrical rounded tops, their glossy leaves ever whispering to the slightest breeze, their glorious golden heads, when the first frosts come, their almost perfect adaptation to the condition of the valleys in which we live, make them most excellent trees to have about out homes.

The Valley Cottonwood *(Populus Fremontii Wislizeni).* This is the common tree of the lower irrigable valleys of all the southwestern arid region from the Rio Grande to the Pacific, and forms much the greater part of the "bosques" of the Rio Grande, the Gila and the lower Pecos valleys. Wherever the land is under cultivation, this cottonwood is used more or less as a shade tree, or in a few cases, for windbreaks. It is a particularly rapid grower, and in the valleys where the water table is but a few feet below the surface, these trees

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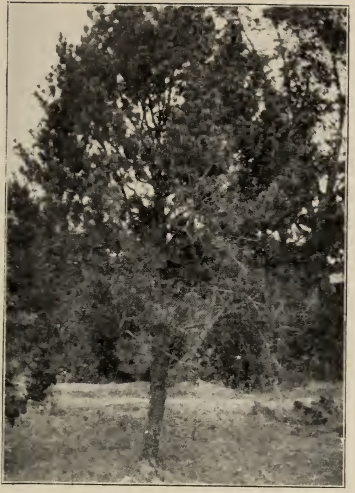
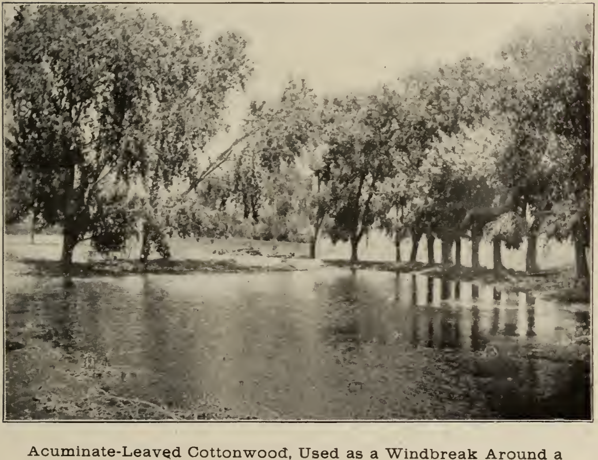
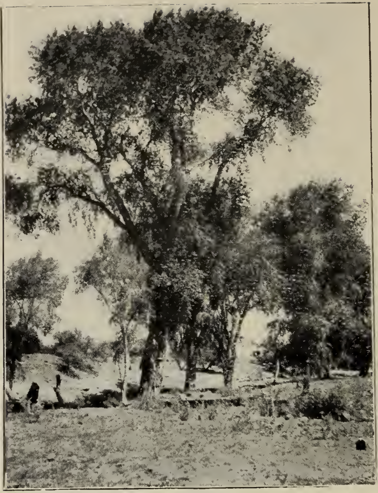
* Possibly it would be wise to explain just what is meant by the staminate trees, for the benefit of those who have not studied botany. The cottonwoods belong to that group of plants in which the two organs necessary to the production of seed (i. e. stamens and pistils) are borne upon separate trees. The stamens furnish the pollen, (or yellow fertilizing dust) and after the very simple flowers which contain the stamens cease blooming, the trees bearing them show no further evidence of being concerned in seed production. The troublesome cotton consists of numerous hairs which surround the seeds to assist in their distribution, hence is only produced by the seed bearing or "female" trees. The staminate flowers are reddish or brownish or sometimes a dull yellow, and hang in pendulous spikes which appear on the trees before the leaves. They show no sign of the green berry like balls which contain the seed The pistillate catkins, however, are green, and each flower consists of little else than a rudimentary ball with the expanded stigma above it. There are fewer flowers on these catkins and they usually appear with the first leaves or a little later.



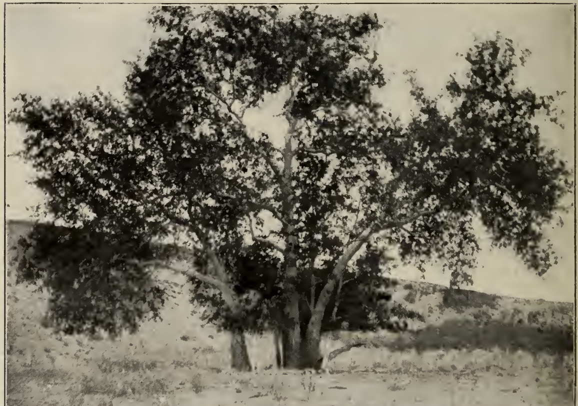
PIÑON. Grown in the Valley. About 30 years old.



Acuminate-Leaved Cottonwood, Used as a Windbreak Around a Reservoir.



Mountain Cottonwood.



Sycamore

soon get their roots down to the water and do not need to be irrigated. As has already been suggested, it is necessary to protect them, at least in the southern part of the Territory, from attacks of the mistletoe. The tree grows fifty or sixty feet high under favorable conditions, forming a symmetrical rounded head with gracefully arching branches and is effective for street use. When grown alone and frequently pollarded, as is the too common custom in the Mesilla valley, it is apt to become short and bunchy. The author has seen it used very effectively to produce a high arched open green canopy over a house which was thus rendered most pleasantly cool in the warmest weather. The tree may be recognized by its broadly triangular leaves, which are nearly as broad as they are long.

Another cottonwood which is fully as effective and offers a slightly denser shade is the acuminate leaved cottonwood, *(Populus acuminata)*, which has narrowly oval, taper-pointed, and darker green leaves. This tree is used as much or more than the valley cottonwood on the streets of Deming and Silver City. It would, no doubt, grow well in any of the towns and valleys of the Territory where it could be given a limited amount of care and water.

The Mountain Cottonwood. *(Populus angustifolia)* grows native along the streams in our mountains at elevations of from 5,500 feet to about 7,500 feet above the sea level. It is an exceedingly graceful tree with rough grayish bark and dark green, glossy, willow-like leaves and makes a very desirable shade tree, especially at the higher levels in the Territory. It has been grown quite successfully at Lincoln, where it is preferred to the valley cottonwood. It is certainly worthy of more general adoption.

The Quaking Aspen *(Populus tremuloides)* is really a cottonwood and should be used much more than it is. As shade trees they are not valuable because the top is small and thin, but used in clusters in connection with conifers, their white stems would be as effective as the birch of the eastern states. They probably would grow only at the high levels.

Willows. Closely related to the cottonwoods and usually associated with them are the willows. There are a number of species native in the Territory but most of them are but small shrubs bordering the streams and ditch banks.

The Black Willow *(Salix nigra)* becomes a tree twenty to thirty feet high in favorable localities and its spreading crown is often broader than it is high. This tree grows readily in sandy soil where the water is near the surface and could be used most effectively for shade and windbreaks about reservoirs or for shelter belts in the lowest of the valley lands or along ditch banks. It is the common willow tree of the river valleys, being almost as abundant in the Gila valley in New Mexico as is the cottonwood.

The Mountain Ash *(Fraxinus velutina)* is perhaps as satisfactory a tree for general decorative and shade purposes as grows native in the Territory, and its value is appreciated in the Mesilla valley where it is used quite extensively. The common name is a local one and does not refer to the shrub which ordinarily goes under that name in the eastern and central states *(Sorbus Americana)*. It is a true ash. It naturally grows in the rocky cañons and dry water-courses of the warmer more barren portions of the mountains, and here it attains a height of thirty to forty feet. The trunk is straight; the bark is a light brownish-gray and quite smooth even in good sized trees; the branches grow obliquely upward with rather a sharp angle and are stiff enough to bear their own weight thus giving the tree a symmetrical head. The foliage is rather pale green, not very dense, appears rather late in spring, and is rarely ever hurt by late frosts. While not as rapid a grower as the valley cottonwood, the mountain ash is a vigorous and healthy tree in cultivation. The mistletoe attacks it but slightly and the winged fruits are never sufficiently abundant to be a nuisance. Young trees may be obtained in the cañons of nearly any of the mountains in southern New Mexico at altitudes below 6,500 feet and are easily transplanted any time when the leaves are off.

The Box Elder *(Negundo aceroides)* is also a favorite as a native shade tree, and it is worthy of the praise it receives. A graceful, round-topped, symmetrical tree of this species forty to fifty feet in height may be produced in a relatively short time if conditions are favorable. The native habitat of the tree is in the lower levels of the Territory, where it is associated with the valley cottonwood, the black willow, the mountain ash and a few other less common trees, in the open irrigated valleys or along streams in the broken country at elevations below 6,500 feet. Here it may be found or it may be grown from seed. Those who are not familiar with it can recognize it by its general similarity to the maples, but its wood is softer and spongier, its leaves are light green and composed of three separate leaflets, and the young growing stems are green. The fruit is of the common winged type of the maples. It requires treatment similar to the valley cottonwood or mountain ash.

Maples *(Acer spp).* There are two native species of maple which grow in the higher mountains (from 6,500 to 9,000 feet) of the Territory but neither are of any particular importance as trees. The red maple *(Acer glabrum)* becomes a low tree twelve to eighteen feet high and may be recognized by its red growing twigs and leaves having three separate leaflets. The other *(A. grandidentatum)* has light gray, almost whitish, smooth, bark, even on the younger limbs, and the usual simple lobed leaves which have coarse blunt teeth and lobes with rounded sinuses between the lobes. It usually forms a large spreading shrub rather than a true tree. What might be done with them in cultivation is hard to tell, though they would probably be useful for variety on large lawns or in parks. They could be grown at the higher elevations in the Territory. Like the cultivated maples, their foliage is generally brilliantly colored just before the leaves fall. If a large lawn or park were to be decorated, a few of them might be used for the sake of their brilliant autumnal foliage alone.

The Soapberry Tree *(Sapindus marginatus)* has been introduced into cultivation in a few localities with some succes. It is well worth cultivating and will stand the conditions found in the lower, warmer and drier parts of our Territory. The tree is of medium size with straight trunk, smoothish light brown bark, round head and light green foliage. The leaves are of the compound type something like the walnut, from six inches to a foot in length, but the separate leaflets are narrowly lanceolate in shape, about two inches long, and without any marginal teeth. In the spring these trees bear rather large panicles (four to six inches long) of small dull white flowers, which are followed by a scattering cluster of brownish berries each of which contains a single ellipsoidal brown seed one-fourth of an inch in length. The plants may be grown from the seed, or young trees a foot or two in height may be obtained in the lower parts of the mountain ranges in warm rocky cañons. In its native habitat the tree is of slow growth and relatively small, but in cultivation it grows more rapidly and is a slightly darker green.

The Walnut or Nogal *(Juglans rupestris)* is a native tree which deserves more attention in this region. It grows naturally in our mountains at elevations of from 4,500 to 6,500 feet, and is not uncommon in the valleys and "draws" tributary to the Gila river. The tree resembles the black walnut of the Mississippi Valley states in most respects, except that it is generally smaller in size, and the "nuts" are only about half to two-thirds as large as the black walnut. We have not yet raised any of these trees and the author has never yet seen a young tree, hence accurate data as to methods of cultivating them can not be given here; but it is altogether likely that it will be necessary to plant the "nuts" where the tree is expected to grow, as trees of this kind rarely stand transplanting well. It may be advisable to soak the seeds for a time in order to get them to sprout freely.*

The Sycamore *(Platanus Wrightii)* is another native tree that

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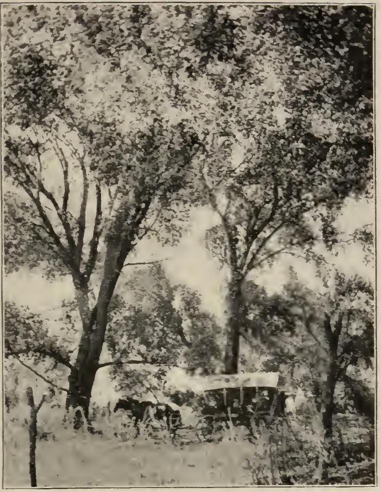
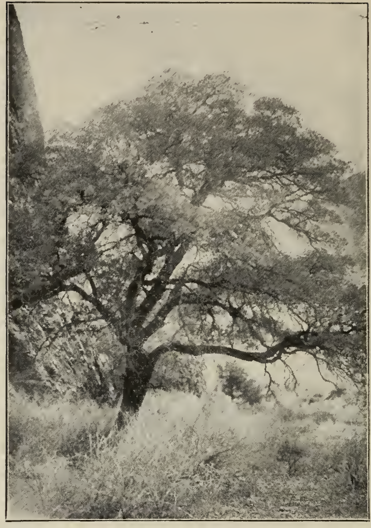
* Timely hints for Farmers No. 50, Arizona Experiment Station. Dec., 1903. Prof. Thornber here recommends that hard seeds be soaked in hot water for a short time, or in luke warm water for several hours. He also recommends "Stratifying" for some hard seeds. This paper should be consulted for accurate data as to temperature of water and time of soaking.

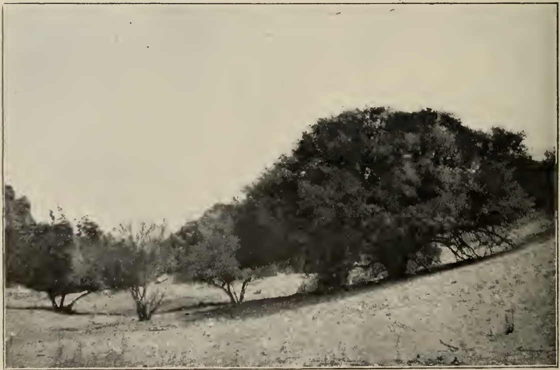


Valley Cottonwood. Showing habit when not cut back.

Black Willow.



Live Oak. (Q. Arizonica.)



Live Oak. (Q. Oblongifolia.)

might be used for decorative purposes. It grows naturally in the southwestern part of our Territory, so far as I have seen, only in the foothills of the mountains in the region of the Gila and its tributaries. This tree attains a height of sixty to seventy feet, is not infrequently twenty-four to thirty inches in diameter at the butt, has a wide spreading open head, smooth, flaky, whitish gray bark, and large palmate leaves whose five long acuminate lobes hang downward in a cluster with points almost touching. It may be rather difficult to get into cultivation.

There is a **Wild Mulberry** *(Morus microphylla)* which grows in the drier cañons of the mountains at elevations below 6,000 feet that might be introduced into cultivation quite readily, but it is doubtful whether it would have any advantage over the Russian Mulberry*, unless it be in the absence of fruit.

The **Hackberry** of this region *(Celtis reticulata)* is a spreading tree which might be used very profitably and effectively in certain locations. It naturally grows on the drier, warmer slopes of our rougher mountains and in the arroyos at their bases. It retains the smallish reticulated leaves until quite late in the fall, and is one of the freshest and greenest of the green things to be seen in the early spring. Its leaves become quite dark green in the summer and the shade which the tree produces is denser than that of any of the trees which naturally grow with it. The fruit of this tree is much like the hackberry of the eastern states, except that when ripe it is tan colored, but it is of no value. This tree is particularly adapted to dry rocky soils which are very warm. It thrives on a very small amount of water and in situations very unfavorable for most other trees.

The **Oaks** of New Mexico are more numerous than is generally supposed and three or four of them might be used very effectively for decorative purposes. They are generally known as scrub-oak, including several species of evergreen trees having low widely spreading crowns; the white oaks, with dark deeply lobed deciduous leaves; the black oak, with rather rough bark and glossy spiny leaves; and the silver leaved oak, which has narrowly oblong leaves that are glossy on the upper surface and white and wooly beneath. The evergreen species usually have relatively small bluish green leaves which are either smooth along the margin or have a few more or less spiny teeth. The deciduous leaved oaks have larger (three to five inches long) leaves which have several rounded or incised lobes and are chrome-green in color.

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* See Bulletin No. 47 of this Station, p. 22.

The Silver-Leaved Oak (*Quercus hypoleuca)* would be as valuable in cultivation as any of the native oaks, and it is certainly beautiful enough, as a mature tree to pay for considerable work and trouble to get it started. In its native habitat it may be seen in the form of a good sized shrub forming clumps, and also as separate trees of considerable size. In either condition it is particularly attractive because of its peculiar foliage which is evergreen.

The Black Oak of the southwest (*Quercus Emoryi)* is a small tree with very dark rough bark and glossy evergreen leaves. Its branches are usually relatively slender and, where supplied with plenty of water, the tree is rather a free grower and is quite graceful. It grows naturally at elevations of from 4,500 to 6,000 feet in the drier parts of the mountains of the southwestern part of our Territory. It will stand almost any degree of dryness.

Scrub Oaks. Several species are included under this general name, some of which are evergreen and some are deciduous. None of them reach any considerable size and are of no particular horticultural value, unless they might be used as hedge plants.

Live Oaks. This name is indiscriminately applied to several low, round-topped trees of the warm, dry hillsides in the juniper zone. They are of very slow growth, so slow that they would be difficult to grow for shade trees. They have gray, rather smooth bark and small bluish green leaves that are rarely over two and one-half inches long, have a few stiff teeth, and are thick and tough. They are sufficiently picturesque to warrant their retention if found already grown, instead of cutting them down as is usually done, and they are so hardy in their native habitat that they will submit to almost any treatment.

The White Oaks also comprise several nearly related deciduous-leaved species found in our higher mountains where they obtain considerable moisture. They might be used effectively at the higher elevations in the Territory. They would undoubtedly grow at much lower elevations than where they grow naturally, if they were given plenty of water. These species drop their leaves during the winter season. Their leaves are relatively large (three to five inches), deeply lobed, or incised, bright chrome green, and relatively thin.

The Alder *(Alnus acuminata)* is a tree found growing along our mountain streams which would be particularly beautiful if it could be brought into cultivation. It reaches a height of fifty to sixty feet, has smooth dark gray bark, branches which rise upward and arch over, dark green leaves which resemble the beech leaf somewhat, and small cone-like fruit. The tree grows freely, associated with the mountain ash, black willow, cottonwood and box elder and would probably lend itself readily to cultivation. It can probably be reproduced from seed, but it may be necessary to plant young trees obtained in the mountains.

The Wild Cherry *(Prunus Capollin)* of the lower levels in the drier mountains makes a very attractive tree with its dark smooth bark, glossy leaves, and pendant racemes of white blossoms. It would no doubt lend itself readily to cultivation and would be well worth any trouble so incurred. In its native habitat, it is one of the most beautiful of the trees of the Territory and one of the most conspicuous of the green things which beautify the mountain cañons in the spring. Its fruit would attract the birds. It would be necessary to protect it from the ravages of the caterpillars which usually destroy the first crop of leaves. This might easily be done by using a torch upon the young caterpillars as they begin to form their web.

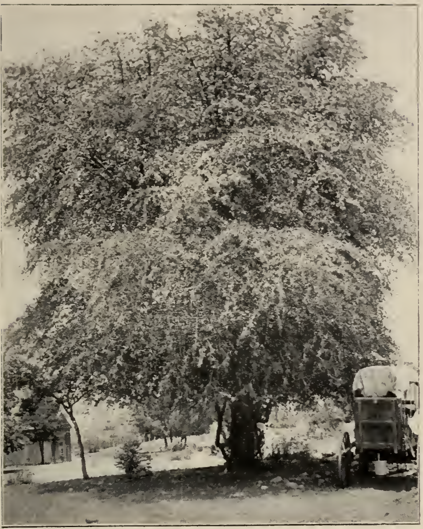
SHRUBS

Notwithstanding the apparent paucity of vegetation of our region there are a number of shrubs which have been or might be introduced into cultivation and which would amply reward all efforts to induce them to grow. Part of these shrubs attain some size and grow naturally at rather high altitudes in the mountains, while others are true desert inhabitants and, with few exceptions do not reach a height of more than four or five feet. Those of the mountain sides are mostly deciduous leaved and would need to be supplied with good soil and plenty of water, while those from the mesas will endure almost any degree of drouth and thrive in almost any kind of soil. Most of the latter class retain their leaves from year to year, and for this reason are all the better adapted to certain kinds of uses.

Syringa or **Mock Orange** *(Philadelphus spp.)* There are three species of this shrub to be found growing in the mountains at elevations of from 6,000 to 9,000 feet. They all have the showy white flowers of the cultivated species. *P. argyrocalyx* grows to a height of eight or ten feet and produces numerous flowers one to one and a half inches in diameter that have a silvery-white hairy calyx; its leaves are oval and about an inch long, silky hairy beneath and smooth along the margin.

P. microphyllus resembles this species tolerably closely, while *P. serpyllifolius* is a smaller bush with much smaller leaves, and flowers about half the size of those described.

Closely related to the above and resembling them somewhat is another shrub of our barren mountains. It is without a common name so far as I have been able to learn: its scientific name is *Fendlera rupicola*, being named (generically) after August Fendler who was one of the first botanical collectors in the Territory. The blossoms are about an inch in diameter, with four pink-tinged white petals. The leaves are small and narrow, rarely over an inch long and one-fourth as wide. The shrub is not infrequently six or seven feet high and flowers profusely in May, though the blooming season may be delayed until later in the summer.



Black Oak.

Walnut. Nogal.

Soapberry Tree.

Candalabrum Cactus La Cholla.

Another relative of the preceding species is a shrub found in the high mountains along streams, called *Edwinia Americana.* All of the shrubs, so far named, are related to the cultivated hydrangeas, and this one, by its shreddy bark, its opposite, rather large, elliptical, scalloped leaves, and pyramidal panicle of white flowers, suggests the hydrangeas rather strongly. At elevations of 10,000 feet it is usually from two to four feet high; but at lower elevations, where it gets plenty of water, I have seen bushes six to seven feet high. It is quite a pretty shrub when well grown and in full bloom.

Holodiscus australis is the botanical name of a rather large shrub which I have heard called Wild Crape Myrtle, but I do not believe this name is extensively used. The shrub frequently reaches the height of ten feet and produces numerous flat panicles of small cream colored flowers. It belongs in the rose family and the flower clusters quite strongly resemble those of the cultivated *Spireas* to which it is nearly related. It lives in the higher mountains (7,000 to 9,000 feet) among the pines and spruces, but does not seek the shade; hence it would doubtless grow in the open at lower levels if supplied with a good soil and plenty of water. It is well worth cultivating.

New Mexican Black Locust *(Robinia Neo-Mexicana).* Most of us who have spent any time in the mountains in the summer have seen this plant, which frequently attains the size of a small tree. It closely resembles the ordinary black locust but it is a more scraggy grower and its flowers are larger and of a beautiful rose pink color. Well up in the mountains it frequently grows in tolerably large groups which have a characteristic appearance. It has been successfully transplanted at this Station, but it is a slow grower and has a poor form. Grown with other shrubs it would give variety, but it is not satisfactory for much else.

Algerita*, or **Barberry** *(Berberis haematocarpa).* This is an evergreen shrub found growing naturally at elevations from 5,000 to 6,000 feet in the southern parts of the Territory on dry hillsides, and in the "draws" in the foothills of the mountains. It reaches a height of eight to ten feet in favorable locations and forms a bush four or five feet in diameter. The leaves are compound, having three, five and sometimes seven thick, smooth, leathery leaflets, each of which has a few stiff spiny teeth along the margin. They are suggestive of the holly leaves. The bark is stringy and brown; the wood is a bright yellow color and rather tough; the flowers are small, light yellow, and borne in clusters about three inches long, blooming in May and June; the fruits are bright red berries, a little larger than currants, and are ripe in August. In some parts of the Territory the berries, which are borne in abundance, are used for making a jelly, which is quite good. This shrub should grow very well in cultivation because it grows naturally in conditions which are more severe than those supplied in any garden, and it would amply reward the gardener for his trouble. It would be necessary to transplant small bushes. *Berberis Fremontii* is a shrub which closely resembles the Algerita, except that its fruit is dark blue and dry. It grows in similar situations further west and north, reaching New Mexico only along the western side. *Berberis Fendleri* is a spiny shrub, three or four feet high, with simple obovate leaves and golden yellow flowers, first collected on Santa Fe creek. It would probably come into cultivation readily.

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* I can find no authority for this spelling, which is a mixture of Spanish and English. I have heard the word only in the mouths of Americans and think it may be a corruption of a Spanish word. It certainly is not Spanish as it stands.

The Desert Willow or **Mimbres** (*Chilopsis linearis*) has already been brought into cultivation and its nursery varieties are to be had of progressive nurserymen. The native species reaches the size of a tolerably large branching tree in the southwestern part of the Territory. It generally grows in the form of a loose straggling bush with several stems rising in a cluster from the root, and may be found in most of the rocky arroyos leading from the mountains. Its branches are slender, graceful, smooth and willow-like, and its narrow leaves add to this resemblance; but its flowers appear in rather large clusters of whitish blooms at the ends of the stems. They are somewhat similar in shape to catalpa blossoms but have rose purple blotches and spots on the corolla. The fruit is a slender cylindrical pod about six inches long which also resembles the pod of the catalpa. The desert willow may be pruned as a small tree: in this form or as a bush, it is a very effective ornament in early June when it is in full bloom. Rooted plants are easily transplanted from the arroyos.

Associated with the desert willow is a rosaceous plant sometimes called Poñel by the Mexicans, (its botanical name is *Fallugia paradoxa*), which would be tolerably valuable in cultivation. It is a shrub that reaches a height of six or eight feet in favorable localities. It has small dissected leaves which are covered with yellowish hair on the under surface; its flowers are bright white and about the size of a pear blossom, which they resemble slightly, but are borne singly on slender stems; they are followed by spherical heads of plumose, long-tailed seed-pods which are greenish with a reddish tinge. These plants are easy to transplant and will stand large amounts of sunlight and must have a moderate amount of water.

Certainly one of the most beautiful of our native shrubs is *Garrya Wrightii*, a bush which is not infrequently ten or even twelve feet high. It grows in the rocky cañons of the mountains at elevations under 6,500 feet. The leaves are elliptical, entire, about one to two inches long, and bright green; and, what is better, they remain green all the year. The flowers are inconspicuous whitish blossoms and are followed by slender clusters of dry, blue-black berries. So far, we have not succeeded in getting this plant into cultivatian but hope to make it grow. A hedge of such plants would be a very valuable windbreak in the spring, as well as add much to the appearance of a yard or garden.

Lemita. Three-Leaved Sumac. *(Rhus trilobata).* This is a many-stemmed shrub which grows upon our dry mesas, in the rocky arroyos in the mountains, and on our ditch banks in the valley. It has been used to some extent in cultivation in this valley, and grows luxuriantly when given a moderate amount of water. It produces long slender stems which are inclined to trail. The leaves are compound, having three obovate, scalloped leaflets one to two inches long; the inconspicuous yellow flowers appear before the leaves in the spring; the fruit is a cluster of small hairy, orange-scarlet berries each of which is but a seed with a small amount of pulp attached and surrounded by the dry bladdery skin. Its leaves are deciduous,

A nearly related species is *Rhus virens*, with evergreen compound leaves having seven to nine oblong, thickish, shining leaflets. It forms a small branching shrub four or five feet high.

The Golden Currant or **Buffalo Currant** *(Ribes aureum)* is a very desirable shrub for cultivation and one whose beauties have long been appreciated. It grows wild in our mountains and along some of the streams. It becomes a rounded bush five feet or more high, and in the early spring is covered with beautiful, yellow, tubular flowers about one inch long and most pleasantly spicy fragrant. The berry is at first yellow but turns black when ripe. The shrub is easily transplanted and may be divided.

Roses *(Rosa spp)*. There are several species of wild roses in the Territory which have been more or less cultivated. The commonest is *Rosa Fendleri* of the higher mountains, with its delicate pink flowers and slender, graceful, dark-red stems. It grows well in cultivation in this valley. *Rosa stellata* has about the largest blossoms of any of the wild roses, and they are deep crimson in color, but as yet we have not succeeded in getting it to do well in cultivation.

Garrambullo (*Lycium Torreyi*). This is a relative of the eastern "Matrimony Vine," and becomes a low thick-set shrub. Its numerous, stiff, spreading spine-like branches form an itricate net-work of stems. The leaves are small, thickish and fascicled. The flowers are small, tubular, greenish purple, and followed by small scarlet tomato-like berries which the Mexican children seem to relish. The leaves open early in the spring, and the plant needs relatively litle water. It is common in the arroyos and on the sand hills of the valley. As a hedge plant it would be a decided success.

In the northern and eastern parts of the Territory and adjoining states, there grows a shrubby Morning Glory (*Ipomoea leptophylla*) which becomes from two to four feet high, and bears numerous large, purplish-pink flowers that look like the common morning glories. The plant has a very large tuberous root and narrow leaves two to four inches long, while the flowers are about three inches long. It would probably grow readily from seed.

There are two perennial plants found growing upon our driest mesas which are without doubt the colder, arid land equivalents of the palms and their allies, found in the tropics. The Mexican people have recognized the resemblance and have called the broader leaved one *La Palma*, and the narrow leaved species *La Palmilla*; and the names are well applied. We call the larger plant the Spanish Bayonet. though the Latin generic name of *Yucca* is getting to be more commonly used. The narrow leaved species, being more useful and somewhat less dangerous, has received the less euphonious name of Soapweed, because its roots make a good soap.

Most people see very little of value in these plants, but they, with others of their associates, offer a number of horticultural possibilities. The one quality of paramount importance which these plants possess is their perfect adaptation to arid conditions, which must be endured in many places where it is very desirable to have some vegetation. Attention has already been called to the appearance of many of the cattle ranches of the Territory, and there is no doubt that the owners of many of these ranches excuse themselves from any exertion towards adding vegetation to their surroundings by saying that nothing will grow on our mesas. These two plants (as well as some others) are living refutations of their excuses. Not only they will grow, but they will grow well, and what is better still, plants of these species of any size and age may be transplanted with but little danger of loss. When it is remembered that a "Spanish Bayonet" or "Soapweed" eight or ten feet high, is probably as old as a cottonwood a foot in diameter, it seems strange that so few of these *Yuccas* die when transplanted. And they are to be had for the digging, any place in the southern part of our Territory.

Another advantage possessed by these plants, is that they are always in full leaf and green; and their wax-like blossoms, when they come are most beautiful. For massing, for hedges, for formal bedding plants, and for low windbreaks they are most effective. A hedge or windbreak six feet high may be had fully grown for the planting, and such a hedge will give protection to other less vigorous and yet valuable smaller plants. Without doubt there are many places where the *Yuccas* may be used effectively for beauty and comfort, but they will not become large shade-casting trees, though they may reach a height of eighteen or twenty feet. However, we should recognize their usefulness within their limits and utilize them in locations where practically nothing else will grow.

Spanish Bayonet, Spanish Dagger, La Palma (*Yucca macrocarpa*). This is the broad and stiff leaved species which is common on the mesas in the southern part of the Territory. Ordinarily it has a straight stem six to eight inches in diameter and four to eight feet high with a head of stiff spreading leaves about four feet in diameter at the top. Under favorable conditions this plant will reach a height of eighteen or twenty feet. The stem is usually simple, but sometimes it branches either at the base or some distance from the ground. When it branches from the ground it not infrequently makes beautiful formal bedding plants, producing a mass of radiating green leaves which is almost geometrically perfect. This plant is particularly easy to transplant, because its under-ground stem is rarely over eighteen inches long, and its roots are small and fibrous, thus rendering the digging relatively easy. A very little water in excess of the rainfall during the first season after transplanting will prevent its dying and then it can take care of itself. The loss in transplanting large plants of this species will not average two per cent.

Soapweed, La Palmilla, Amole (*Yucca radiosa*). This is the tall narrow leaved species of *Yucca*, and in my opinion is the more beautiful plant of the two. Its leaves are slender (half an inch wide or less), flexible, and very numerous; its flower-stalk is much taller, its blooms make a better showing, and its stem is more often branched. For hedges and windbreaks it is better because it has thicker heads. But its tap root extends below the surface from four to six feet, and it is often necessary to cut it off in digging the plants, thus causing a greater percentage of loss. Of fifty-two plants which I have transplanted, twenty-five per cent. of them died; these plants were put in a soil where there was much more alkali than that in which they naturally grow and were generally subjected to worse treatment than they ordinarily get; hence a part of the loss may be due to these causes.

Sotol (*Dasylirion Wheeleri*). This is a near relative of the *Yuccas* and is usually found more or less closely associated with them. Its stem is usually short (less than four feet) and crowned with a head of numerous, flat, radiating, strap-shaped, flexible leaves whose margins have many hooked teeth. These plants usually grow among the rocks and are hard to dig; young plants transplant the more readily. They are valuable for formal masses of bedding plants, or bedding plants, or against a hedge row. The bloom stalk is frequently eight feet high; the flowers are small and of two kinds (staminate and pistilate) borne on different plants.

Bear Grass (*Nolina spp*). Plants somewhat closely resembling the last. The leaves, however, are stiffer and thicker (sometimes triangular in cross section) and without the teeth, though frequently rough. The flowers are small and white. borne in a central panicle varying in height (as does the plant) with the species. They might be used effectively any place where the Sotol would grow.

Candlewood, Ocotillo (*Fouquiera splendens*). This spiny shrub is frequently used for fences by the Mexicans and sometimes as a guard for young shade trees. In a formal bed associated with Cacti, Sotol, Bear Grass, and *Yuccas* it adds much to the variety, particularly when its spiny wand-like stems are tipped with clusters of brilliant scarlet flowers.

Century Plant, Mescal (*Agave spp*). There are several species of these rather well known plants native here and they readily adapt themselves to garden conditions.

Cacti. Numbers of species of these truly desert plants are found here. The Cholla or Candelabrum Cactus (*Opuntia arborescens*). The flat jointed Prickly Pears or Nopales, (*Opuntia spp.*), the Barrel Cactus or Bisnaga (*Echinocactus Wislizeni*) and several species of *Cereus* are to be had for a desert garden, and add much to its beauty by their queer form and brilliant wax-like flowers.

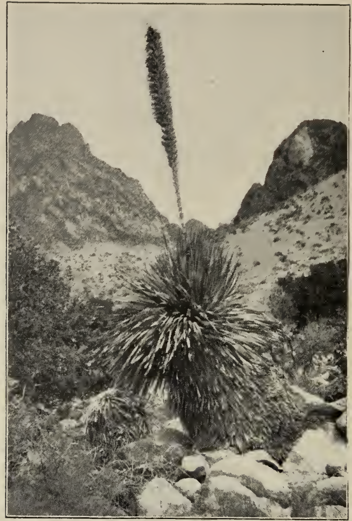
Creosote Bush, Hediondilla (*Covillea tridentata*). This is an evergreen shrub of the mesas which would make an excellent low hedge plant. The worst drawback in connection with it seems to be the difficulty in transplanting it. A few people have succeeded, but as yet I have not, though I have tried several times. It is very deeply rooted and the roots are relatively large for the size of the plant.

VINES

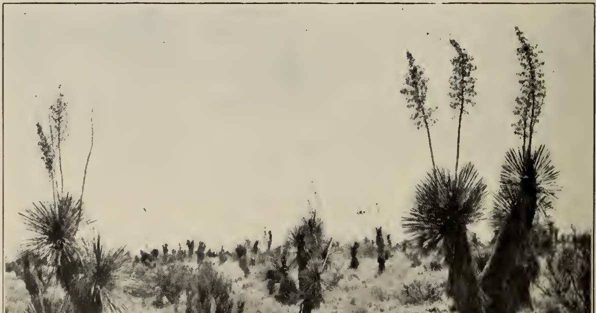
It is doubtful whether any kind of vegetation gives more genuine satisfaction about a house than well kept vines. They may be used as a screen over an arbor or a porch to give shade; they may be grown over a low trellis and give the effect of a hedge; they may, in favorable conditions, be induced to climb over the surface of a wall on a woven wire support near the wall and so give the effect of an ivy both in appearance and shade. Nothing is more satisfactory for modifying the light admitted to a porch than a screen of vines; nothing so quickly, so satisfactorily, and so beautifully covers unsightly out-buildings and fences as some of our native vines. Generally speaking, the perennial vines are the more satisfactory because they need only to leaf out in the spring to be thoroughly effective, while the annual vine must grow from the ground each season and rarely reaches its full effectiveness

Fendlera Rupicola.

Spanish Bayonet. La Palma.



Sotol.



La Palmilla at Home.

until the summer is well advanced. Besides the quality and general adaptiveness, vines are especially valuable because of their rapidity of growth: they produce their favorable results in a very short time after planting. This is a thoroughly satisfying quality because it is so tiresome to think of the long years that must elapse before the small trees will amount to anything; particularly tiresome if one needs shade badly. Under such conditions it is well to plant vines, at least for temporary results, until the trees can grow.

Virginia Creeper *(Parthenocissus quinquefolia)* is referred to* as one of our most valuable vines and recommended for use. The fact that it is such a satisfactory plant in cultivation here is rather a strong argument in support of the use of our native flora, since this species is native in our mountains. It may be simply because of the general adaptability of this widely distributed species, but at any rate, it would suggest the wisdom of trying others of our native vines and shrubs. The details of the methods of cultivation may be found in the bulletin referred to. It may be used practically any place where a vine will grow and it is especially rapid and vigorous. The more water it receives the more rapidly it grows, but absolute lack of water in the middle of the summer does not kill it; it merely stops growing vigorously and seems to wait for the water.

Clematis. There are several native species of *Clematis* that thrive well in the Territory and it is likely that most species of the genus could be grown here satisfactorily. *Clematis ligusticifolia* is the species which inhabits the ditch banks in most of our valleys, though not confined to such locations. It has large clusters of white flowers each of which is about an inch in diameter, and is followed by a head of feathery tailed seed pods. The leaves are compound and the vine climbs by twisting the small stems of the separate leaflets around the smaller parts of the support provided, whether it be dead or living tree or the lattice work of a porch. This vine is very vigorous, and while it will endure very adverse conditions without dying, it appreciates and rewards a gardener's care. *Clematis Drummondii* is a near relative of the preceding species, which lives upon the mesas and in the foothills of our drier mountains. Its flowers are small and more inconspicuous, the feathery seed pods are longer tailed and less numerous, and the leaves are smaller. Altogether it is not as attractive a plant, though it will no doubt stand greater dryness in the soil. *Clematis Bigelovii* is a species with single flowers on long peduncles; the sepals are maroon-colored, thick and leathery and white-hairy within. The compound leaves have oval entire leaflets mostly, though some of them are deeply lobed; all are smooth and veiny. This is a vigorous vine, well worth cultivating, which grows in the mountains at elevations of about 5,500 feet. *Clematis occidentalis* of the northern part of the Territory would probably do well in cultivation while *C. orientalis* has become to a degree naturalized at Las Vegas.* All of these species of the *Clematis* have perennial roots which are easily divided and transplanted. The first named species grows readily from layers and would probably do well from cuttings. They are all quite hardy, though *C. Bigelovii* would stand less drouth than some of the others; none of them will winter-kill in the Territory.

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* Bulletin No. 47 of this Station, p. 48.

Hop Vine *(Homulus Lupulus Neo-Mexicanus)*. The New Mexico variety of the hop vine is the one found growing along the creeks of our high mountains at elevations of from 6,000 to 8,000 feet altitude. It is a root perennial but slightly different from the cultivated species and may be grown readily from the divided roots. The vine is herbaceous, persisting for but one season, but it is an exceedingly rapid grower. It will cover a tall trellis before the middle of the summer.† The roots to start these vines may be found growing wild in almost any of our mountains, or they possibly might be started from the seed. Transplanting the roots would generally be the most satisfactory way.

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* Ckll. in Science X n. s. p. 898. "An Alien Clematis in New Mexico."

† See Bulletin No. 47 this Station, p. 46.

Wild Grapes *(Vitis spp).* Any of the native grape vines would grow with ordinary care under cultivation and they are particularly beautiful vines for ornamental purposes. Their glossy green leaves furnish a very dense shade, and the perfume of their blossoms is of that peculiar pleasant kind which seems to be a kind of evanescent nasal beverage that does not cloy. Smelling the flowers rarely gives the effect; it is the atmosphere some little distance from them that bears the perfume whence the most delicate and delicious drafts may be obtained. For use over arbors or trellises, over dead stumps of trees, or on unsightly buildings there is hardly a native vine which would make a more beautiful covering. Transplanting the roots would be the sure way to get them into cultivation, though it is probable that cuttings would grow readily.

Wild Honey-Suckle (*Lonicera albiflora*) This is a slow growing vine, or sometimes it assumes almost the form of a low shrub (*L. dumosa*) that grows in our mountains. The leaves are oval, about an inch long and covered with a "bloom;" those of the shrubby plant are generally soft hairy on the lower surface. The upper pair of leaves is united at the base forming a cup in which is borne the small cluster of odorless whitish flowers. The bark on the younger stems is inclined to be shreddy. The fruit is a small berry. This honey-suckle would no doubt come into cultivation readily and would probably grow more freely thus than in its natural habitat, since it lives usually on the dry rocky hillsides where plant growth is most difficult.

Maurandia Vine (*Maurandia Wislizeni*). Perhaps the most valuable annual for our dry hot locations is the above named vine which grows wild clambering over low bushes on our sand hills and mesas. It may be recognized by its leaves, which are somewhat like arrow-heads with flaring bases (hastate), about one to one and a half inches long, and its tubular light blue flowers. It may be grown readily from the seeds, which should be planted in September, and the young seedlings will live through the winter without freezing. Our hot summer sun has no terrors for this vine nor does dry weather daunt it; it grows on to the end of the season when it produces abundance of seed. I have succeeded in transplanting seedlings in the winter, but this is rather hard to do as the tap root is quite long and the young rootlets are near the tip of it.

Philabertella cynanchoides is the botanical name of what might possibly be called a vine milk weed. It has narrowly heart shaped leaves, less than two inches long, and small clusters (umbels) of whitish clove-scented flowers which closely resemble those of the milk weed. This plant also has milky sap. It grows readily along our ditches and streams at the lower levels rising from a perennial root, which could be transplanted with little difficulty. For a low climber this vine would be very satisfactory and its sweet scented flowers would be desirable in any garden.

Morning Glory (*Ipomœa Mexicana*). It is but necessary to call attention to the ornamental possibilities of our native morning glory which grows readily from seed. As a field weed, it is a nuisance, but as a vine for trellises and the like, it is decidedly valuable. There is another closely related vine (*Quamoclit coccinea hederacea*) growing in our mountains at low elevations which has slender tubular scarlet flowers that resemble the cypress blossom.

The cucumber or melon family furnish three or four vines which might be used in cultivation. One of them the Melon Loco (*Apodanthera undulta*) is a coarse, rough, creeping vine with circular crisped leaves, three or four inches in diameter and gourd-like fruit. It has a thick perennial root and will stand any amount of drouth. It would be well grown with Cacti. It is propagated readily by seeds or transplanting the roots. *Ibervillea tripartita* is a small vine with dissected mottled dark and light green leaves and small scarlet tomato-like berries, which grows among the mesquite bushes on our mesas and which would be an addition to a bed of arid land plants. It could be propagated from seeds. The One-Seeded Bur Cucumber (*Sicyos spp*). is a rapid growing vine of our high

La Palmilla and Vines Banked Against a Fence.

Clematis and Maurandia Covering a Wire Fence.

Sacaton. Seven Feet High.

Creosote Bush. Hediondilla.

mountains, with five-angled, thin, yellowish-green leaves and inconspicuous yellow flowers. The vine is very delicate and climbs by means of tendrils. It could be grown in damp soil and somewhat sheltered places, from seed.

HERBACEOUS ANNUALS AND PERENNIALS

Besides the plants already enumerated there are a number of smaller herbaceous annuals and perennials which might be cultivated with profit, especially in gardens where there is but a moderate supply of water available. But only a few of the more prominent ones need be mentioned here.

Of those taken from the mountains (and they need as much water as ordinary cultivated plants) the Columbine (*Aquilegia spp*). of which there are three species growing native in the Territory, is very easily cultivated. There are several species of Larkspur (*Delphinium*) which will also do well in cultivation. Several species of *Polemonium*, both yellow and blue would be valuable additions to any garden, while *Pentstemons* and *Gilias*, white and blue, and various shades of red, and *Phlox* of two or three species are to be found in the mountains. A species of Lady's slipper (*Cypripedium Veganum*) has been recommended for cultivation.*

Of the plants which live in the drier localities and which will grow on practically any soil, not excepting a sand-bed, might be mentioned the *Abronias* (three species) which resemble somewhat the garden verbenas and are very fragrant; the *Datura* with its large, funnel-shaped, purplish-tinged, white blossoms which are borne so profusely and are so sweet; the various *Asters*, both white and purple; the wild *Zinnias*; the *Baileya* with its double yellow flowers and white-hairy leaves and stems; the beautiful pink-flowered *Polypteris*, besides a a host of others which cannot be allowed space here.

There are three or four native grasses which might be used effectively in clumps for decorative purposes, especially if placed before dark green backgrounds, such as may be obtained by massing evergreens. **Saccaton** (*Sporobolus Wrightii*) is a large grass reaching a height of five or six feet in favorable situations and having a widely spreading graceful panicle. It forms clumps two to three feet in diameter. **Bunch Grass** (*Sporobolus airoides*) is a smaller, though very similar grass well adapted to dry alkaline soils; it grows about two and one-half to three feet high. *Muhlenbergia distichophylla* is a grass of our drier mountains which suggests a small pampas grass and would be very decorative. **Carrizo** (*Phragmites phragmites*). This is a cane-like grass which lives naturally only in moist soils. It grows about six or eight feet high, has broad leaves and a spreading plume-like panicle eight or ten inches long. This common name is also applied to a very nearly related introduced grass (*Arundo donax*)* which is more valuable than the native species for several reasons.

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* Prof. T. D. A. Cockrell tells me that this plant has been successfully brought into cultivation by Mrs. Joshua Reynolds of Las Vegas.

A good sod grass is a desideratum in our Territory, especially in the lower and warmer parts. None of the native grasses promise to supply this demand and at present nothing better than the Bermuda grass has been found. It has several drawbacks, and, like the cottonwood, a number of people have no use for it, but for arid conditions where a small amount of *clear* water can be supplied, a number of its qualities recommend it strongly.

At some of the higher levels blue grass has been induced to grow very well. In such locations the sod grass question has been solved.

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* See Bulletin No. 47 this Station, p. 49.

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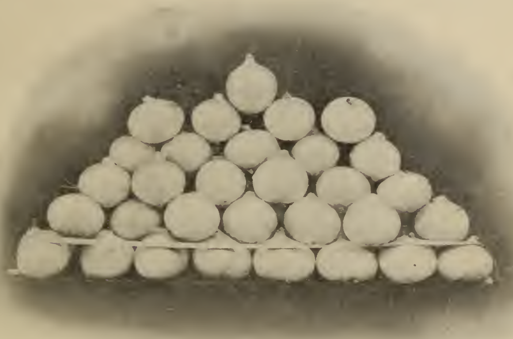
BULLETIN NO. 52

SEPTEMBER 1904

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.



Gigantic Gibraltar Onions—an excellent variety. Seed planted Oct. 3, 1903; transplanted March 12, 1904; harvested August 27, 1904.

ONION CULTURE

BY

FABIÁN GARCÍA

SANTA FÉ, N. M.:
NEW MEXICAN PRINTING COMPANY,
1904.

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ONION CULTURE*

Introduction

Onions can be grown successfully in many parts of New Mexico. Some sections seem to be particularly adapted to the growing of certain varieties. In the Rio Grande valley, for example, the old "El Paso" onion, which is of the Spanish type, grows to perfection, and in the past this valley, especially the lower portion, has had quite a reputation for growing this variety. Owing to the great difference in altitude and climatic conditions throughout the Territory, there is no doubt that the methods of treatment of the crop in the lower and warmer valleys is somewhat different from those employed in the mountains and more elevated regions. Perhaps one of the chief differences is in regard to the time of sowing the seed, which is, usually done later in the season in the higher and cooler sections.

It appears that there is a general lack of interest in onion growing, and every indication points to the cultivation of a less acreage than formerly. Even the famous "El Paso" variety is exceedingly hard to secure. The production is so small that a large per cent. of the onions consumed, even in the best onion growing districts of the Territory, are brought in from other states. In many of our towns, California onions usually retail for five cents per pound throughout the year. It is to be regretted that such a state of affairs should exist, especially when fine onions can be grown in the Territory. If enough onions cannot be grown for shipping, at least a sufficient quantity should be grown for home consumption.

The onion would make a good crop for the gardener or the small farmer to grow. Of course, it should be kept in mind that onions are expensive to raise, but as a rule they are among the best paying crops. It should also be understood by the beginner in onion-growing that raising this crop, in order to get the best results, requires close attention and much hard work.

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* A Spanish edition of this Bulletin has also been issued.

During the past three seasons, the Experiment Station has been conducting experiments in onion-growing on a small scale. The principal features of the investigations have been as follows:—testing of varieties, method of culture, and the keeping qualities of the varieties grown, and ascertaining cost of production and yield.

Soil

The character of the soil on which onions are grown in this section has a great deal to do with the yield. If the onions are grown on a hard adobe soil which packs and bakes considerably after being irrigated, the bulbs will not develop as large nor as evenly as when grown in a light, rich soil. As a rule, a soil that becomes hard and packs around the bulbs tends to reduce the size of the bulbs and the yield. The onion, which is a shallow feeder, needs a light, rich, moist soil; one that is loose and has plenty of available plant food close to the surface. If the soil is thin or poor, even if it is light, the yield will be low.

"The Old Method" of Seeding

This applies to the method of sowing the seed in the field. If the onion crop is grown by this method, the ground must be thoroughly prepared for the reception of the seed. Since the soils—even the lighter ones of this Valley—have a tendency to run together and pack when irrigated, it is of the utmost importance to prepare a good seed-bed. The soil frequently packs so much, after being watered a few times to produce germination, that the seeds come up slowly and unevenly. The difficulty may be obviated to a certain degree by drilling the seed on the sides of ridges and irrigating in the furrows. It is necessary, however, to be careful that the water does not cover the seeds on the ridges, for if it does they will have about as hard a time coming through as when grown in plats. While the ridge system of starting the plants, as a rule, gives better germination, it is more expensive than level culture. The distance between the rows depends on the method of cultivation and irrigation. If the furrow and ridge system is to be followed, the ridges are plowed up not less than three feet apart and then leveled to about ten inches on top. Two rows, four or five inches apart, are drilled in on each ridge. If hand culture and the flooding system of irrigation is practiced, the rows are planted fifteen inches apart; but, if the field is to be cultivated by horse, thirty inches is about the minimum distance between the rows. The seed is sown about one inch deep with a hand drill, and irrigated immediately after to start germination. Ordinarily it will take four to six pounds of seed to the acre, when sown in the field. It is well to use a liberal supply of seed since it is more likely that a good stand will be secured.

While sowing the seed out in the field is the old and a very common way of growing onions, it does not seem to be as satisfactory with our conditions as the so-called "New Method," which we have found preferable. As far as can be ascertained now, most, if not all of the onions grown in New Mexico are produced according to the old way which, as already stated, consists in planting the seed out in the field and thinning the plants to the required distance in the row. As a rule better results can be had if the seed is planted in the fall, during September and the first of October. The seed-bed should be kept well irrigated during the winter.

Thinning in the Field

When the seed has been started in the fall, the thinning of the onions can be done during March or the first of April. Thinning should be done as early in the spring as possible. Thinning onions, when properly done, is a laborious and expensive operation,—more so than is generally considered by most of the onion growers. There are always a lot of vacant spots in the rows due usually to poor germination. This means that onions have to be transplanted in these vacant spots. It is slow work to thin out the small onions and leave in place, at the proper distance in the row, the plants that are to remain without disturbing them. If the onions are quite thick and have come up in bunches, and if the soil is at all hard or sticky, the thinning is a still slower and more difficult process. If the workmen are not careful, they are liable to pull all of the onions and not leave the one in its proper place. If this is done, it is then necessary to transplant one of the onions where the bunch was, which practically amounts to the same thing as transplanting.

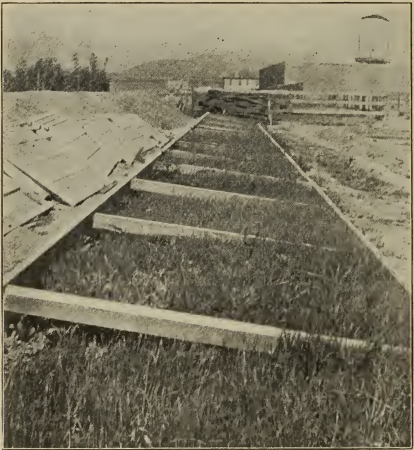

Fig. 1—Onions Started in a Cold Frame Ready for Trans-Planting.

An idea may be had of what it costs to thin onions in the field, where irrigation is practiced, from the following results obtained at the Experiment Station on a small plat, in 1902. One-tenth of an acre plat, which had been seeded to onions, was thinned out in the spring. The rows in this plat were 15 inches apart, while the onions were left every 4 inches in the row. The cost of thinning this plat was $4.10. At this rate, the thinning of an acre would be $41.00.

"New Method"

This consists in growing the onion seedlings in a cold frame or seed-bed, and then transplanting them to the field. This plan, while not really new, is being advocated by many of the onion-growers as being better than the old way. The operation of transplanting onions is slow and is usually considered an expensive one. For this reason, the inexperienced onion-grower is liable to think it is too laborious and not a paying proposition; but, as a matter of fact, it is no more expensive than the thinning of onions in the field. The results of the experiments with onions at the Experiment Station show that it is cheaper to transplant than to thin a given area.

Onion Seed

Seed should be purchased from reliable firms, even though it may cost more, for it always pays to get good fresh seed. Cheap onion seed is liable to be poor and may mean mixed varieties, lack of uniformity in the crop, or the production of scullions. Farmers and gardeners frequently buy their seed in the small packets which are sold at the local stores. This is not a good practice, as such seed is liable to be quite old. Onion seed is slow to germinate and the little plants are delicate and slender-rooted at first. The fresher and more vigorous the seed, the better the germination and the stronger the plants. The germinative vitality of onion seed decreases quite rapidly with age. Our seed was secured from W. A. Burpee's of Philadelphia.

Time to Sow Seed for Transplanting

As already stated, in the Mesilla Valley the seed should be started in the fall, early enough for the onions to make a good root system before the cold season comes. In order to have the plants large enough to transplant out early in the spring, the seed should be sown in the open seed-bed some time in September or during the earlier part of October. If the seed is started in cold frames covered with glass, it can be sown later. Care must be taken to keep the seed-bed or cold frame well irrigated during the winter. A quarter of a pound of seed is usually enough to sow a seed bed six feet wide and from fifteen to twenty-four feet long, making ninety to one hundred and fourteen square feet. In case the size of the seed-bed is changed, it should be made larger instead of smaller. The seed is usually planted in drills three to four inches apart. If the germination is good, the seedlings will be quite thick in the drill. At this rate, it will take from 3 to 4 and a half pounds of seed to the acre. This is about one and a half pounds less than when planted in the field.

Preparation of Land for Transplanting

In preparing land for transplanting onions, it should first be irrigated, then plowed, disced or harrowed, and smoothed.

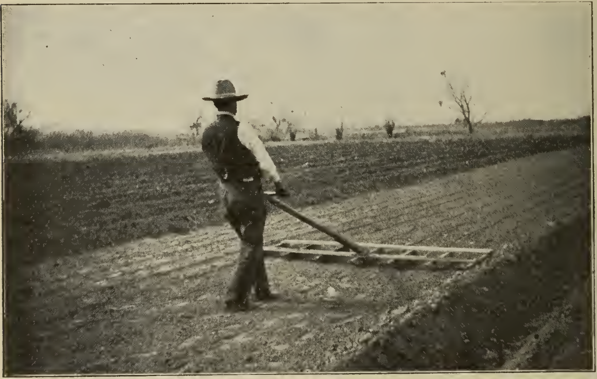

Figure 2—Home-Made Marker for Marking Rows for Onions.

After this, the rows should be laid off. This can be done by means of the home-made marker shown in Figure 2. It is a good idea not to prepare the land until the transplanting is to be done. If the land is prepared too long before the onions are set out, it will pack down and get hard and dry, and at the same time the weeds may make a considerable growth. If the land is moist and loose, the transplanting will be more easily and quickly done, as the dibber or garden trowel, which are good tools to use in this operation, make better holes for the onions to be placed in. When the ground is too dry, as the dibber or garden trowel is taken out in making the hole, the dirt is likely to fall back in and fill the hole up. Such a soil condition tends to retard the work of transplanting.

Transplanting

The onion is a crop which requires a cool season to develop most advantageously. From the results of the experiments at the Station, it has been found that better results are obtained when the transplanting is done early enough in the season, so that the plant will make most of its growth before the hot and dry months of June and July. The latter part of February or early part of March has been found to be a very good time for transplanting in the Mesilla Valley.

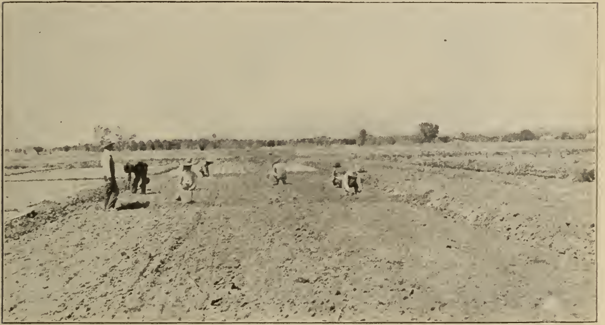

Figure 3.—Transplanting Onions.

Many of the onion growers advise that the onions should be about the size of a lead pencil before they are transplanted. While this is a safe rule to follow, one should not be entirely bound by it. Frequently the onions are not quite that size by the time they should be set out. This means that the transplanting will have to be delayed or that the onions must be set out before they get to be the size of a lead pencil. It seems to be a safer plan to transplant the onions at the proper season, though they be smaller than the size recommended, than to delay the transplanting until the onions grow larger. Many of the onions set out in the year 1903 at the Station were about half as large as a lead pencil, and some were even smaller. In 1904, all of the onions set out were about half the size that they should have been, according to the rule. Practically all grew and the results did not seem to be influenced by the size of the onion seedlings.

In transplanting a large number of onions, it is a good plan to do the work quickly; that is, to have enough help so that a large number of onions can be set out in a short time, in order that the first ones may not suffer before they are irrigated. It is also a good plan to have a boy drop the onion seedlings a little ahead of the men transplanting; in fact, better time can be made this way than when each man carries a bunch of onions and stops to pull one out every time before it is planted. If the boy works rapidly, he can drop enough for three transplanters. However, he must not drop too far ahead of the men, as the onions will wilt considerably before they are transplanted. About 5,000 is a good number for one man to transplant in a day.

Distance to Transplant

One of the principal things in view in raising onions is to produce a large yield; and in order to do this, all of the soil must be utilized to the best advantage. Most of the onion growers in the Rio Grande valley allow too much land to each onion. Ordinarily, the onions are planted about twelve inches in each direction and in this way the land is not made to produce all it can. The most common distance, where "hand culture" is practised, seems to be from twelve to fifteen inches between the rows and from four to four and a half inches in the row. Setting the onions out at these distances gives a larger number to the acre, varying from 100,000 to 120,000 onions or more. On the other hand, if "horse culture" is employed, the distance between the rows is usually increased to at least thirty inches, thus reducing the number of onions to the acre.

Cost of Transplanting

Some idea may be had from the following as to the cost of transplanting onions. A one-tenth acre plat was transplanted with onions grown in a cold-frame in 1902. The rows were practically 335 feet long by 15 inches apart with the onions four inches in the row, making 1,005 onions to the row, or 10,050 to the plat. The cost of transplanting this plat of onions amounted to $2.95. This included, besides the cost of transplanting, that of the first irrigation, bringing the onions from the seed-bed to the field, and dropping them ahead of the men transplanting, about the proper distance in the row. At this rate, it would cost $29.50 to transplant an acre or 100,500 onions,—practically one-fourth cheaper than to thin the same area. In 1903, a one-fifth acre plat was transplanted on the 14th of March. The rows were 15 inches apart, and the onions four inches apart in the row. The cost of transplanting this plat was $6.00. At this rate, the estimated cost per acre would come to $30.00. In the spring of 1904, another one-fifth acre plat was transplanted, the onions being set out the same distance as in the previous years. It cost $5.70 to transplant this plat. This would make one acre cost $28.50. The average estimated cost per acre for the three years amounts to $29.33.

Irrigation

Immediately after the onions are set out, they must be irrigated, and this should be followed with a second irrigation in about seven to eight days. Usually it takes about two irrigations to establish the little plants. The subsequent irrigations will vary more or less, depending on the soil and climatic conditions. Other things being favorable, the time between the irrigations to get good results, should be about every eight or twelve days. Since the onion is a surface feeder, it is very desirable that the upper portion of the soil be kept moist and cool. If possible, the plats should be arranged so that any excess of water may be drained off after each irrigation, especially on adobe soils. Care should also be taken not to allow the water to stand too long on the land. The soil must be kept uniformly moist throughout the growing period of the onion. If the soil becomes too dry, so that the plants stop growing and is then irrigated, the tendency is for many of the onions—especially if this occurs after the bulbs have made a considerable growth—to split into two or more parts. If this occurs, a part of the crop is liable to become unsalable.

Irrigation with Muddy Water

On July 30th, 1904, the onions were irrigated with very muddy ditch water. This water was so exceedingly thick with sediment that it was not safe to irrigate alfalfa, beans, tomatoes, and vines. The water, which had only been in the ditch about a week, was from the heavy rains which fell in what is known as the "Rio Puerco" region. The water that comes down this river is always very muddy, and usually considered not good to use, except on such plants as trees, corn and vegetables growing on ridges, such as chili.

At the time these onions were irrigated it was impossible to use pump water, and since the crop needed another irrigation before harvesting, the ditch water was used. Realizing the bad effects such muddy water generally has on many plants, before applying it, the writer inquired of the old time gardeners about the advisability of using such water on onions. The concensus of opinion doubted the advisability of using the water. A few of the gardeners believed the more developed bulbs would decay. In view of the lack of any definite information concerning this matter, it was thought this was a good opportunity to get some data on this subject. The onions were irrigated as heavily as at any other time during the season. After the water was dried up the sediment was so thick that all the bulbs were covered up with it. Two days after the irrigation, cloudy and rainy weather set in. For five days thereafter it rained enongh to keep the sticky sediment from drying up. At first, it looked as if the onions would rot; it was twelve days before the sediment dried up enough so that the ground could be worked. On August thirteenth, the onions were examined and it was found that they had not been injured by the muddy water.

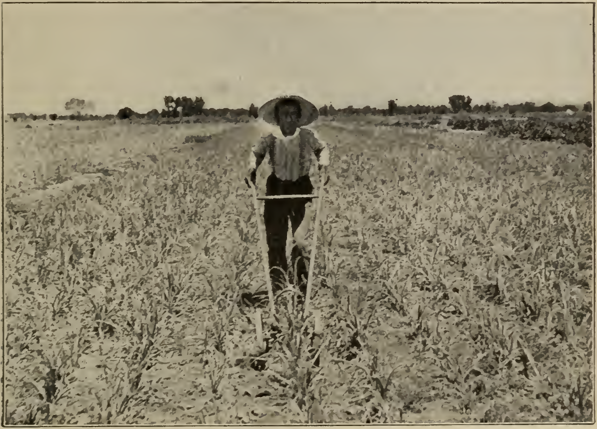

Figure 4.—Using the "Planet Jr." Double Wheel-Hoe.

Number of Irrigations

In 1904, the one-fifth acre plat was irrigated twelve times. The first, second, and last irrigations were given with water from the ditch. All other irrigations were made with water from the Station pumping plant. The water from the ditch failed soon after March 21st, and the ditch remained dry until about the last of July.

The following are the dates of irrigation: March 12th, 21st, and 31st, April 16th, May 5th and 20th, June 5th and 22nd, July 7th, 15th, 22nd, and 30th.

Cultivation

As already stated, the onion delights in a loose, rich soil. In order to keep the soil loose, it must be kept stirred throughout the growing season. The cultivation of the onion is simple; it consists in keeping the soil loose and the weeds down. If possible, cultivate after every two irrigations. If "hand culture" is practised, the cultivation can be done with the "Planet Jr." double wheel hoe. This is the implement usually recommended for such work, and the one we have found to be the most helpful; it not only stirs up the soil and leaves it in good condition, but it also destroys all the weeds in the middles. Two or three hand weedings may be necessary during the earlier stages of growth. This operation consists mainly in taking out the weeds between the plants in the row. A narrow hoe, or Lang's Hand Weeder, are helpful tools.

The following table shows the dates of and the time required for each cultivation on the one-fifth acre plat during 1904:

April	20th,	Cultivating,	7	hours,	10	min.
"	22–23,	Weeding	14	"	20	"
May	9th,	Cultivating,	4	"	55	"
"	16–17,	Weeding,	12	"	30	"
"	25th,	Cultivating,	7	"	10	"
June	11th,	Cultivating,	7	"	10	"
"	13th,	Weeding,	8	"	55	"
"	20th,	Weeding,	7	"	25	"
"	29th,	Cultivating,	5	"	20	"

Horse Culture

It is believed by many of the gardeners of this section that it is more profitable to cultivate by horse than by hand. While it is true that work can be done more easily and perhaps more quickly by means of a horse, there are but half as many plants to the acre as would be planted when hand culture is practiced. The rows should be about thirty inches apart—wide enough for a horse to walk between the rows. On the other hand when the work is done by means of a wheel-hoe, the rows are about fifteen inches apart, making twice as many rows to a given area, and, accordingly the yield would be greater. In using the horse cultivator, there are usually about six inches of space on each side of the row of onions that has to be cultivated by either the wheel-hoe or ordinary hand hoe. In the end much of the work done in fields where horse culture is practiced, is done by hand.

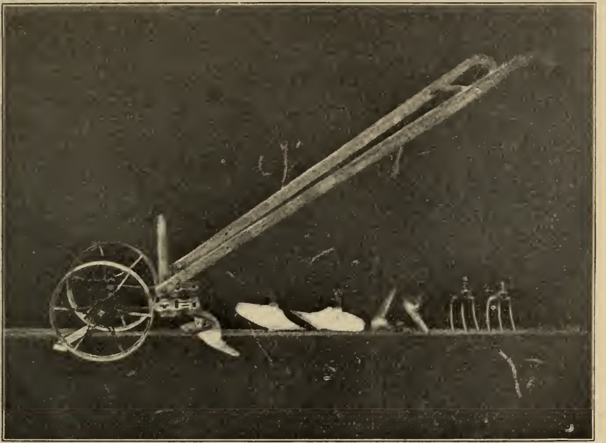

Figure 5.—"Planet Jr." Double Wheel-Hoe.

Harvesting

When the tops turn yellow and are beginning to die, the onions are ready to be harvested. This operation should not be delayed. Irrigation must stop when the ripening begins. Onions usually ripen unevenly, and some specimens will be green when most of the crop is ready to pull. It is not always a safe plan to wait until all of the tops are dried up; better pull the onions a few days too soon than a few days too late. If they are left too long in the field after ripening, especially during wet weather, there is danger of some of them starting a new growth. A few days' delay after a new growth sets in may spoil a large part of the crop. The onions may be made to ripen more evenly if the tops be bent down at ripening time.

Topping

It is better not to remove the tops until after the onions have been pulled up and sunned for a day or so. The tops can be cut off with an ordinary pair of pruning shears, and these we find to be preferable to a knife. About half an inch from the bulb is a good place to cut the tops off. It is better not to cut the tops any shorter than this.

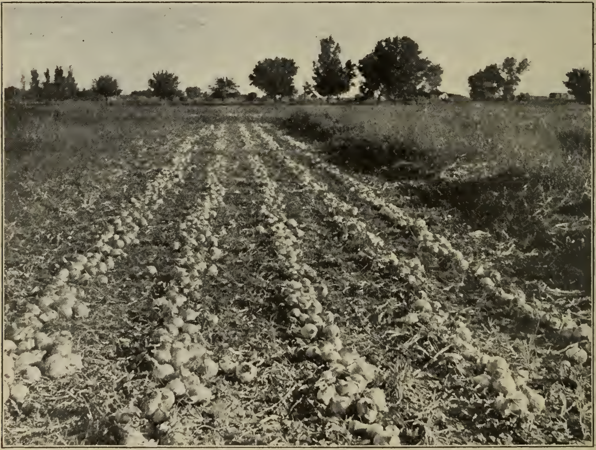

Figure 6.—Onions Being Sunned in the Field Shortly After Topping Them

Storing

If the onions are to be stored, after they are pulled, leave them out in the field a day or two. Care should be taken that the sun does not burn them. Some of the white varieties, such as the Early White Queen and the White Pearl, &c., have thin skins and are easily burned by the sun. The onions should be perfectly dry before they go into the store room. Onions may appear to be perfectly dry and yet they will start to sprouting, causing quite a loss in some cases. It is not a good plan to let them stand in piles before they dry up, since they are liable to heat. The usual method of storing onions is to place them in crib-like shelves where they will have a free circulation of air. The layers may be from eight to twelve inches thick.

Yield

Since the onion is a very expensive crop to grow, it is very important that as large a crop as possible be produced. The yield varies considerably, however. From three hundred to one thousand bushels per acre is the range in some of the onion-growing states, and a yield of from four to six hundred bushels is a good average crop. In New Mexico it is not yet definitely known what the average yield is per acre, although the yield at the Experiment Station in 1903 was very satifactory. Two varieties, the Red Victoria and Prize Taker, grown on small plats, produced at the rate of 32,000 and 29,000 pounds of marketable onions per acre respectively. The onions were set out about the fifteenth of March. The land on which they grew received no special treatment whatever; the previous year the land was seeded to winter wheat and in the fall the stubble was plowed under and winter irrigated. In 1904 the yield was also very satisfactory. The land on which the crop grew this season was not as good for onions as that used the previous year. The Prize Taker produced at the rate of 25,680 pounds per acre, while the Gigantic Gibraltar, which was harvested August 27th, yielded at the rate of 31,250 pounds per acre. A one-twenty-fifth acre plat, which was fertilized with sodium nitrate, produced 1,618 pounds or at the rate of 40,450 pounds per acre.

In 1902 the yield was not satisfactory; the one-tenth acre on which the onions grew produced 1,185 pounds of marketable onions, which is practically 12,000 pounds per acre. This is too low a yield and it might not pay to grow onions at this rate. The low yield secured in 1902 seems to have been largely due to the crop being set out so late in the season, and to the hard adobe soil in which the onions grew. The plats were transplanted the last of April. Another trouble that had something to do with the low yield of the crop was the splitting of a large part of the onions, which resulted from the second growth setting in after the onions were ripening. This second growth seems to have been due to rainy weather.

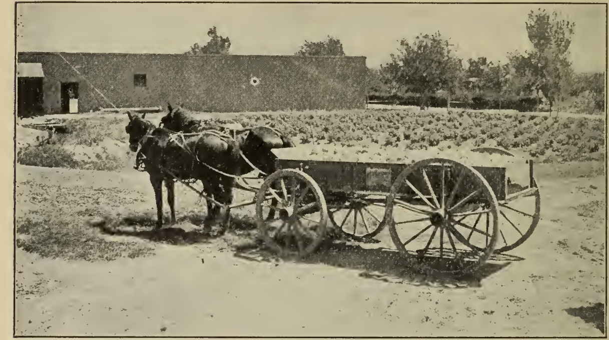

Fig 7. Load of 1,618 pounds of onions from the 1-25 acre plat, fertilized with sodium nitrate.

Cost of Production

As has already been stated, onions are expensive to grow, and especially where fertilizers have to be used, but at the same time they are among the best paying crops. For the purpose of comparison, the cost of production in the East and South is given, as well as the cost at this Station. In "Onions for Profit," T. Greiner gives the following estimated cost of the crop per acre in the East:

Rent of land	$ 6 00
Manure, three car-loads, at $16	48 00
Fertilizers	25 00
Hauling and applying manure	12 00
Plowing and Harrowing	3 00
Marking	1 00
Raising 180,000 plants	30 00
Seed	7 00
Transplanting	45 00
Cultivation and weeding	20 00
Pulling crop	3 00
Gathering, hauling and packing	35 00
Total	$235 00

Prof. P. H. Rolfs, in his book on "Vegetable Growing in the South," gives the cost of growing an acre of onions, not including crates, commission and freight, as follows:

Raising plants	$ 30 00
Rent of land	4 00
Fertilizer and applying it	100 00
Plowing and clearing	4 00
Transplanting	40 00
Seed	5 00
Cultivating	20 00
Harvesting	45 00
Total	$248 00

The results at the Experiment Station show that the cost of production is less than the above figures represent. In the experiments at the Station, the rent of land and the cost of the fertilizers is not included. The following is the actual cost of growing one tenth of an acre of onions at the Station in 1902:

Plowing and leveling land	$ 30
Marking and bordering land	20

Transplanting	$ 2 95
Cultivating and irrigating	2 90
Harvesting, topping and hauling	2 95
Seed	35
Growing the plants, about	1 05
Total	$ 10 70
Estimated cost per acre, ten times	107. 00

This amount does not include crates, commission, or freight.

The cost of production was slightly higher for 1903 than for the previous year. The following is the actual cost of one-fifth of an acre:

Plowing and leveling	$ 60
Marking and bordering land	50
Transplanting	6 00
Cultivating and irrigating	5 15
Harvesting, topping and hauling	7 10
Seed	70
Growing sets, about	2 00
Total	$22 05

Estimated cost per acre will be five times this amount, or $110.25.

In 1904 the cost of raising one-fifth acre plat of onions was as follows:

Plowing and leveling land	$ 70
Marking and bordering	55
Transplanting	5 70
*Cultivating and irrigating	6 15
Harvesting, topping and hauling	6 50
Seed	75
Raising sets	2 00
Total	$22 35

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*The cost of pumping the well water is not included.

At this rate, the estimated cost per acre will come to five times $22.35 or $111.75.

Thus it is seen that, according to these estimates, it is possible to grow onions cheaper here than in some of the onion-growing sections in other states. Since the cost of production is less and the yield equal to if not greater than that of other states, it seems that onion raising could be made profitable in many parts of the Territory, provided the crop can be sold to advantage.

Varieties

With onions as with other plants, some varieties are better suited than others to different sections. Of the number tested at the Experiment Station, some have been found to do poorly, while others have given very satisfactory results.

The Early White Queen, Barletta, White Bermuda and the Extra Early White Pearl are quite satisfactory for early ripening. As a rule, they are not good keepers. The bulbs are medium in size, flat, and with a thin, glossy white skin; the tops are also small. They are very mild onions. The Early White Queen is perhaps the best all round table onion in the test. The Red Victoria has given the best yields of any of the varieties in unfertilized soils. It is a very large and somewhat globe-shaped onion, and a medium keeper. If a large, red and fair keeper but heavy yielding onion is desired, the Red Victoria would be recommended. The Prize Taker and Gigantic Gibraltar are both very good keepers and excellent yielders. These onions are yellow in color, globe-shaped, and very solid. They look very much alike in every respect. The Gigantic Gibraltar is preferable to the other two mentioned. The Australian Brown has given very satisfactory results as a late keeping variety. It is medium in size, brown, and very solid; ripens early and is a sure cropper. It will always make bulbs—whether conditions are favorable or not. It is not as heavy a yielder as the other onions mentioned.

White Onions

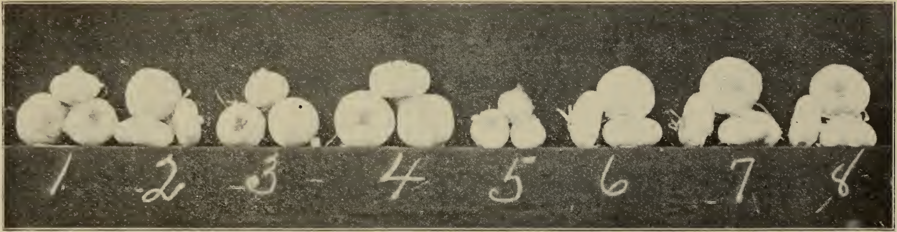

Fig. 8.—1 White Victoria. 2 Extra White Pearl. 3. Large White Globe (True Southport Strain). 4. Giant White Italian Tripoli. 5. Philadelphia Silver Skin, 6. Early White Queen. 7. Neopolitan Maggiojola. 8. New Mammoth Silver King.

Red and Yellow Onions

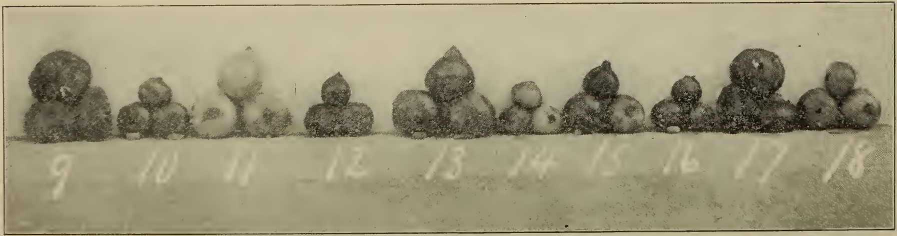

Fig. 9.—9. Mammoth Pompeii. 10 Extra Early Red. 11. Prize Taker. 12. Large Red Globe (True Southport Strain). 13. Red Victoria. 14. Round Yellow Danvers. 15. Australian Brown. 16. Large Red Wethersfield. 17. Mammoth Red Tripoli. 18. New Giant Red Rocca.

Insects and Diseases

As yet no diseases of any kind and no serious insect pests have been observed at the Station, and none have been reported from other sections of the Territory. The Thrips, which is often seriously injurious to onions in other states, was observed in a very limited number last season.

Markets

This subject has received little attention here. We frequently hear that there is no market for this, as well as other crops. As already stated, there are not enough onions grown to even supply the home market throughout the year. There is no doubt that the local merchants would buy more of the product if they were sure of being supplied right along. As long as the production is so small, it need not be expected that markets can be secured. If large quantities of onions were produced, so that shipments could be made on a larger scale, there is no doubt but that better and more permanent markets could be secured within as well as outside the Territory.

Fertilizers*

In the onion-growing states, the practice of applying fertilizers to the land, either in the form of barn-yard manure or as commercial fertilizers, is very necessary in order to increase the yield. While the application of fertilizers would, no doubt, increase the yield per acre of onions in the Mesilla Valley, this practice is not followed here. Good soils will produce heavy yields without any fertilizers. The yield produced during the past two seasons on land without any fertilizer was as large as the average yield reported from other states. However, a beginning has been made to test the fertilizers. In 1904, one twenty-fifth of an acre plat of the Gigantic Gibraltar onion was fertilized with sodium nitrate, obtained from the "Nitrate of Soda Propoganda," of New York. The ground was more or less adobe and tends to pack after an irrigation. The soil in this plat seems to be below the average for onions.

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*This part of the work was done in co-operation with Professor R. F. Hare, Station Chemist.

The onions were transplanted on March 12, 1904, in rows 15 inches apart and four inches in the row. The sodium nitrate was used at the rate of 600 pounds per acre, or 24 pounds per plat, and it was applied at four different times during the season. The following shows the amounts applied and dates of application: May 9th, 4 pounds; May 28th, 6 2-3 pounds; June 11th, 6 2-3 pounds; and June 30th, 6 2-3 pounds. In each case the nitrate was broad cast and then raked in. On May 28th it was observed that the nitrate was already acting on the growth; at this date, the tops of the onions were larger than on onions not fertilized. On June 14th, the rank and vigorous growth was very noticeable. The onions were harvested August 25th and 27th.

The following figures will show in detail the yield from the fertilized and unfertilized plats:

	Fertilized	Unfertilized	Difference
Area	1-25 acre	1-25 acre	
Fertilizer applied	24℔s		
Actual yield	1,618℔s	1,250℔s	
Actual difference			368℔s
Estimated yield per acre	40,450℔s	31,250℔s	
Estimated difference			9,200℔s
At 2c per pound	$809 00	$625 00	
Estimated difference			$184 00

As may be seen from the table, the unfertilized plat, which was given the same treatment, except the application of sodium nitrate, yielded at the rate of 31,250 pounds of onions per acre; while the fertilized plat yielded at the rate of 40,450 pounds per acre, the increase in yield being 9,200 pounds per acre, or 29.6 per cent. If the onions could be marketed at the rate of two cents per pound, this would give an increased value of $184.00 to the acre. Since 600 pounds of nitrate of soda costs $32.40,* and its cost of application to the soil would be about $2.00, there would be a net increase in the profits of $149.60.

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*The Texas Seed and Floral Co., of Dallas, Texas, quotes nitrate of soda at $4.00 per 100 pounds f. o. b , Dallas

The freight rate from Dallas to Mesilla Park, N M , which has been kindly furnished by the local agent of the A., T. & S. F. R. R., is $1.40 per 100 pounds.

Less than 600 pounds may prove to be just as beneficial, and possibly fewer applications. These are points yet to be determined. From the first year's experiments, it would certainly seem to indicate that the application of nitrate of soda increases materially the yield of onions. Further work will be done along this line.

Second Growth

It has been observed during the onion test that, if the growth of the onion is partially or wholly checked while the bulb is developing, there is a tendency—especially among some varieties—to produce an entirely new growth, if the onion starts to growing again. This second growth seems to be the result of an irrigation given after the onions have been allowed to suffer from lack of water. When this second growth occurs, the plant usually divides or splits into two or more parts (Figure 10-1). This dividing of the onion may be of such extent that frequently the bulb is ruined for commercial or keeping purposes. If the onions should stop growing shortly before ripening, it is not considered advisable, judging from the results at the Station, to irrigate them after that. It seems better to harvest the bulbs, though they may be somewhat immature.

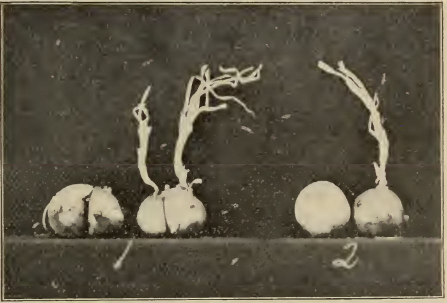

Fig. 10. 1. Bulbs splitting due to second growth.
2. Sound bulbs.

Keeping Test

In the comparative keeping test of the varieties grown, the onions placed on the shelves each year were kept under the same conditions. These tests were carried on for two years, 1902 and 1903. Practically the same varieties were used each year, except that in 1903 the number of varieties was smaller and the onions were placed on the shelves a few days earlier than in the previous year. The shelves were made in sections, one on top of the other on a movable frame, in such a way that the onions when placed in them had a free circulation of air both above and below, as well as from the sides. Where a large number of onions were used, they were two or three deep; otherwise they were only one deep. The frame was placed in one corner of a large adobe room. No fire was kept in it during the winter and most of the time the doors were open in the daytime. The onions were not placed in the shelves until they had dried thoroughly. In 1902, they were placed in the shelves on September 15th, while in 1903 the test started on the 25th of August, thus making the latter lot twenty days longer in the shelves. No rule was adopted as regards the number of specimens of each variety placed in the test. In every case, the most convenient number was taken, as there were only a few bulbs of some of the varieties. The number and weight of each variety were taken at the time the onions were placed in the test. On January 22nd in each year, the onions were sorted, counted, and weighed. In 1902, the specimens were in the test 127 days, while in 1903 they remained 147 days. At the time the observations were taken, three divisions were made of each variety; sound, those that were sound but were just beginning to sprout, and those that had sprouted. Those that were just sprouting, and which were counted in as marketable, were quite solid and by simply cutting off the small sprout they could be utilized at that time. Of course, such onions would become worthless in a short period if no use were made of them immediately.

1903-1904

Observed January 22, 1904

Just sprouting. Marketable.		Sprouted badly. Not marketable		Total weight		Loss in weight during test		
No.	%	No.	%	lbs.	oz.	lbs.	oz.	%
....	....	....	....	....	....	....	....	.....
0	0	0	0	19	0	2	0	9.52
....	....	....	....	....	....	....	....	.....
1	5	0	0	4	11	0	5	6.25
15	60	8	32	7	3	1	5	15.44
23	46	21	42	6	8	2	0	23.52
....	....	....	....	....	....	....	....	.....
5	33.33	6	40	4	14	1	2	18.75
7	46.66	6	40	5	8	2	11	32.82
....	....	....	....	....	....	....	....	.....
3	30	1	10	2	0	0	5	13.51
3	21.42	0	0	3	8	0	8	12.50
0	0	0	0	6	15	0	13	10.48
3	20	9	60	7	5	3	3	30.35
6	60	3	30	4	1	1	7	26.13
6	30	1	5	4	6	0	8	10.00
4	26.66	3	20	5	4	0	12	12.50
5	33.33	9	60	4	3	2	1	33.33
2	10	0	0	4	6	0	8	10.25
3	10	0	0	15	0	0	12	4.76
....	....	....	....	....	....	....	....	.....
11	14.47	7	9.21	33	15	4	1	10.69
0	0	0	0	2	0	0	2	5.88
5	25	0	0	6	11	0	8	6.95
1	4	0	0	7	0	0	12	9.67
10	40	14	56	5	14	2	2	26.56
1	6.66	1	6.66	4	3	0	4	5.63
2	14.28	3	21.42	2	4	0	10	21.73

Keeping Test

Names	1902-1903															1903-1904														
	Date harvested, 1902	No. of bulbs in test	Weight		Observed January 22, 1903											Date harvested, 1903	No. of bulbs in test	Weight		Observed January 22, 1904										
					Sound		Just sprouting. Market-able.		Sprouted badly. Not marketable		Total weight		Loss in weight during test							Sound		Just sprouting. Market-able.		Sprouted badly. Not marketable		Total weight		Loss in weight during test		
			lbs.	oz.	No.	%	No.	%	No.	%	lbs.	oz.	lbs.	oz.	%			lbs.	oz	No.	%	No.	%	No.	%	lbs.	oz.	lbs.	oz.	%
American Prize Taker	Aug. 30	50	7	8	45	90	5	10	0	0	6	12	0	12	10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Australian Brown	" 26	100	14	14	93	93	7	7	0	0	13	13	1	1	7.14	Aug. 15	75	21	0	75	100	0	0	0	0	19	0	2	0	9.52
Australian Yellow Globe	" 30	40	3	6	37	92.5	1	2.5	2	5	2	15	0	7	12.96	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Extra Early Red	" 30	40	4	0	36	90	2	5	2	5	3	8	0	8	12.5	" 15	20	5	0	19	95	1	5	0	0	4	11	0	5	6.25
Extra Early White Pearl	" 15	25	4	8	0	0	3	12	22	88	2	11	1	13	40.27	July 20	25	8	8	2	8	15	60	8	32	7	3	1	5	15.44
Early White Queen	" 15	20	1	14	1	5	7	35	12	60	1	7	0	7	23.33	" 15	50	8	8	6	12	23	46	21	42	6	8	2	0	23.52
Gigantic Gibraltar	" 30	74	19	8	71	95.94	3	4.05	0	0	17	15	1	9	8 01	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Giant Rocca	" 30	37	5	1	7	18.91	10	27.02	20	54.05	4	6	0	11	13.58	Aug. 15	15	6	0	4	26.66	5	33.33	6	40	4	14	1	2	18 75
Giant White Italian Tripoli	" 30	100	17	0	2	2	74	74	24	24	11	14	5	2	30.14	" 15	15	8	3	2	13.33	7	46.66	6	40	5	8	2	11	32.82
Giant Yellow Rocca	Sept. 5	50	9	8	18	36	14	28	18	36	7	12	1	12	18.42	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Large Red Globe (True South Port Strain)	" 5	15	1	3	14	93.33	1	6.66	0	0	1	2	0	1	5.26	" 15	10	2	5	6	60	3	30	1	10	2	0	0	5	13.51
Large Red Wethersfield	Aug. 30	15	1	2	15	100	0	0	0	0	1	1	0	1	5.55	" 15	14	4	0	11	78.57	3	21.42	0	0	3	8	0	8	12.50
Large White Globe (True South Port Strain)	" 30	25	3	4	20	80	2	8	3	12	3	2	0	2	3 81	" 15	25	7	12	25	100	0	0	0	0	6	15	0	13	10.48
Mammoth Pompeii	" 20	50	7	6	4	8	13	26	33	66	5	9	1	13	24.57	" 15	15	10	8	3	20	3	20	9	60	7	5	3	3	30.35
Mammoth Red Tripoli	" 30	40	7	11	4	10	10	25	26	65	5	10	2	1	26.82	" 15	10	5	8	1	10	6	60	3	30	4	1	1	7	26.13
Michigan or Ohio Globe	" 30	20	1	10	16	80	1	5	3	15	1	7	0	3	11.53	" 15	20	5	0	13	65	6	30	1	5	4	8	0	8	10.00
New Giant Red Rocca	" 25	26	4	10	13	50	5	19.23	8	30.76	3	14	0	12	16 21	" 15	15	6	0	8	53.33	4	26.66	3	20	5	4	0	12	12.50
Neapolitan Maggiojola	" 30	25	2	11	2	8	7	28	16	64	1	14	0	13	30.28	July 25	15	6	4	1	6.66	5	33.33	9	60	4	3	2	1	33.33
Philadelphia Silver Skin	" 30	33	3	0	32	96.96	0	0	1	3 03	2	12	0	4	8 33	Aug. 15	20	4	14	18	90	2	10	0	0	4	6	0	8	10.25
Prize Taker	" 25	40	9	0	34	85	2	5	4	10	8	6	0	10	6.94	" 10	30	15	12	27	90	3	10	0	0	15	0	0	12	4.76
Red Bermuda	" 25	45	11	3	1	2.22	13	28 88	31	68.88	8	3	3	0	26.96	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Red Victoria	" 15	60	12	4	19	31.66	15	25	26	43.33	9	1	3	3	26.52	" 5	76	38	0	58	76.31	11	14.47	7	9.21	33	15	4	1	10.69
Round Yellow Danvers	" 30	40	3	12	38	95	2	5	0	0	3	8	0	4	6.66	" 15	15	2	2	15	100	0	0	0	0	2	0	0	2	5.88
South Port Large Yellow Globe	" 30	20	1	13	16	80	2	10	2	10	1	10	0	3	10 37	" 15	20	7	3	15	75	5	25	0	0	6	11	0	8	6.95
White Silver Skin or White Portugal	" 30	25	2	10	18	72	2	5	5	20	2	5	0	5	11.90	" 15	25	7	12	24	96	1	4	0	0	7	0	0	12	9.67
White Victoria	" 30	36	11	0	0	0	10	27 77	26	72.22	8	8	2	8	22.72	" 15	25	8	0	1	4	10	40	14	56	5	14	2	2	26.56
Yellow Dutch Strassbury	" 30	40	4	0	36	90	2	5	2	5	3	9	0	7	10.93	" 15	15	4	7	13	86.66	1	6 66	1	6.66	4	3	0	4	5.63
Yellow Globe Danvers	" 30	25	2	8	17	68	3	12	5	20	2	3	0	5	12.50	" 15	14	2	14	9	64.28	2	14.28	3	21.42	2	4	0	10	21.73

A careful study of the table will show the relative percentages of marketable and unmarketable, etc., of the different varieties. It will also be seen that the best keepers lose less in weight than the poor-keeping kinds. There was practically no loss in weight in these tests from decay; the loss in weight comes from evaporation, scaling off, and sprouting. Small specimens tend to keep longer than larger ones of the same variety. From the data in the above table, the following list of onions have been taken, showing the best and poorest keeping varieties in the test:

List of varieties which average, for the two years, not less than ninety per cent. of sound onions at the end of the test: Australian Brown, American Prize Taker, Australian Yellow Globe, Extra Early Red, Gigantic Gibraltar, Large White Globe (True South Port Strain), Philadelphia Silver Skin, and Round Yellow Danvers.

List of onions, averaging for the two years, not less than eighty per cent. of sound bulbs at the end of the test: Those enumerated in the above, and the Large Red Wethersfield, Prize Taker, Yellow Dutch Strassbury, and White Silver Skin or White Portugal.

Onions averaging for the two years, not less than eighty per cent. of marketable bulbs (sound and those just sprouting): Those already mentioned, and the Large Red Globe (True South Port Strain), Michigan or Ohio Globe, and South Port Large Yellow Globe.

List of onions averaging not over 40 per cent. for the two years, of sound bulbs: Early White Queen, Extra Early White Pearl, Giant Rocca, Giant White Italian Tripoli, Giant Yellow Rocca, Mammoth Red Tripoli, Neapolitan Maggiojola, Red Bermuda, and White Victoria.

The Australian Brown, Gigantic Gibraltar, Prize Taker, and Red Victoria have been grown on a large scale and they have given good results. The rest of the varieties in the first three lists have only been grown in small rows, but the America Prize Taker, Extra Early Red, Large White Globe (True South Port Strain), Philadelphia Silver Skin, White

Silver Skin or White Portugal, and Australian Yellow Globe, are among the most promising kinds. The other varieties grown in rows have given poor results, except for being good keepers.

Descriptions

American Pink Prize Taker—Size medium to large, roundish to globe-shaped, solid, good keeper; color pink.

Australian Brown—Size small to medium, roundish to globe-shaped, very solid. excellent keeper, attractive, ripens early, does not tend to divide; color brown; fair yielder.

Australian Yellow Globe—It looks very much like the Australian Brown, except in color, which is lighter.

Barletta—Size small, flat, poor keeper, early; color white. It is believed to be identical with the Early White Queen.

Extra Early Red—Size small, roundish flat, solid, good keeper, tends to split; color red to purple.

Extra Early White Pearl—Size small to medium, flat, poor keeper, mild, early, no tendency to divide; color white, thin skin.

Early White Queen—Size small to medium, flat, very mild, poor keeper, very early, does not divide; color white, thin skin; fine table variety.

Gigantic Gibraltar—Size large to very large, roundish to globe-shaped, very attractive, good keeper, good yielder and produces a very uniform crop of solid bulbs; color yellow; it is similar to the Prize Taker, except it is lighter in color and the tops, which are large, are not glacous; it is very promising.

Giant Rocca—Size medium, roundish to globe-shaped, attractive, poor keeper, divides badly; color pink.

Giant White Italian Tripoli—Size large, roundish flat, fair keeper, tends to divide; color white, moderately thin skin, attractive.

Large Red Globe (True South Port Strain)—Size small, globe-shaped, fair keeper, there is a slight tendency to divide; color red.

Large Red Wethersfield—Size very small, roundish flat, solid, fair to good keeper, not attractive, poor yielder, tends to divide; color red.

Large White Globe (True South Port Strain)—Size medium to large, globe-shaped, very solid, good keeper, tends to divide; color white; promising.

Mammoth Pompeii—Size very large, flat, poor keeper; there is a slight tendency to divide, medium-sized tops; color red to purple.

Mammoth Red Tripoli—Size large, flat, poor keeper, tends to divide; color red to purple. It resembles the Pompeii.

Michigan or Ohio Yellow Globe—Size small, globe-shaped, fair keeper, tends to divide; color yellow.

New Giant Red Rocca—Size medium, roundish to globe-shaped, very solid, poor keeper, tends to divide; color pink to red.

Neopolitan Maggiojola—Size large, flat, medium-sized tops, poor keeper, tends to divide; color white, thin skin.

Philadelphia Silver Skin—Size small, roundish to globe-shaped, solid, good keeper, divides badly; color white.

Prize Taker—Size large, roundish to globular, solid, attractive, good keeper, and good yielder; a few tend to split; color yellow.

Red Bermuda—Size medium to large, flat, fairly solid, poor to fair keeper; color dark red.

Red Victoria—Size very large, globe-shaped, solid, fair keeper, large tops, there is a slight tendency to split; color dark pink.

Round Yellow Danvers—Size small, roundish to flat to angular, good keeper, divides badly; color yellow; undesirable mostly on account of size.

South Port Large Yellow Globe—Size medium to large, roundish globe, very solid. attractive, fair keeper, there is a slight tendency to divide; color yellow.

White Bermuda—Size small to medium, flat, poor keeper, early, mild, bulbs burn easily by the sun if they are allowed to remain too long out after they have been pulled up; color glossy white; skin thin, small tops.

White Silver Skin or White Portugal—Size medium, roundish to globular, solid, divides slightly, good keeper, promising; color silver white, thin but tough skin, attractive.

White Victoria—Size medium, roundish with a slight tendency to flattening on top, moderately solid, poor keeper, divides badly; color white.

Yellow Dutch or Strassbury — Size small to medium, roundish, semi-globe to angular, very solid, fair to good keeper, there is a slight tendency to divide; medium-sized tops; color yellow.

Yellow Globe Danvers—Size small, globe-shaped, solid, small tops; color yellow; fair keeper, tends to divide.

Summary

1. Onions can be successfully grown in New Mexico.
2. The "New Method" has been more satisfactory at the Station than the old.
3. Onions for transplanting should be started in the early fall, and the seed bed should be kept well irrigated during the winter.
4. Other things being equal, the earlier the transplanting in the spring, the better the results.
5. Very small onions, half as large as a lead pencil, can be transplanted with equally as good results as when they are larger.
6. On rich, loamy soils, very heavy yields can be produced from some of the larger varieties, under ordinary treatment.
7. In stored onions, there is little or no decay; practically the whole loss comes from sprouting.
8. Transplanting is no more expensive than thinning out in the field.
9. The estimated cost of production is less than the cost reported from many other onion-growing states.
10. Under ordinary treatment, the cost need not exceed $125.00 per acre.
11. In order to get a better market and more steady

prices, onions should be grown on a larger scale. As long as the supply is so exceedingly limited, the market is not likely to be bettered.

12. Light and frequent irrigations should be practiced, instead of heavy ones at long intervals.

13. The checking of growth, especially when the bulbs are forming, and then irrigating afterwards, tends to produce a new growth in certain varieties, which, as a rule, is a detriment to the crop.

14. Water should not be allowed to stand too long in the low places. If possible, the plats should be so arranged that all of the extra water due to excessive irrigation can be drained off.

15. The very muddy water, which comes from the "Rio Puerco," does not seem to be injurious to the bulbs.

16. Frequent cultivation is very necessary.

17. The "Planet Jr.," double wheel hoe, does very satisfactory work and is a good labor-saving machine.

18. By bending over the tops at ripening time, the onions seem to mature very evenly.

19. Onions are at present free from any fungous diseases or any insect pests, at the Station.

20. Fertilizers, especially on poor soils, may increase the yield materially.

21. "Hand Culture" is preferable to "horse culture."

22. Onions are not as perishable as many other crops. Many varieties can be kept until late in the season, and thus a better price secured for them.

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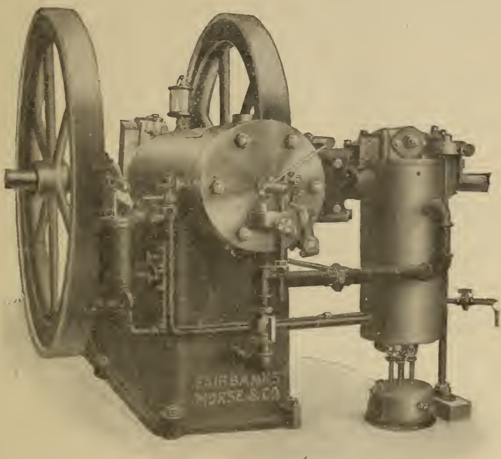
BULLETIN NO. 53

OCTOBER 1904

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.



PUMPING FOR IRRIGATION

A Fuel Test of Crude Oil, Kerosene and Gasoline

BY

JOHN J. VERNON, FRANCIS E. LESTER and HENRY C. McLALLEN

SANTA FE, N. M.:
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The Bulletins of this Station will be mailed free to Citizens of New Mexico and to others as far as the editions printed will allow on application to the Director

SUMMARY AND CONCLUSIONS

1. The equipment used in these tests consisted of a 22 H. P. Fairbanks, Morse & Co's. gasoline engine with a crude oil attachment, and a six-inch centrifugal pump made by the same firm, which was placed upon the six-inch well described in Bulletin No. 45 of this Station.

2. Crude oil from Beaumont, Texas, was successfully used in the above named engine during the short series of tests made on the Station farm.

3. The operation of the engine on crude oil, after its mechanism was understood, was not difficult.

4. Crude oil was proven to be the cheapest fuel yet tested at this Station; that is, cheaper than wood, coal, kerosene, or gasoline. The cost of a ten hour run with the above named engine on each kind of oil was as follows: Crude oil, $3.05, kerosene $6.57, and gasoline $6.65. Therefore, for a ten hour run, crude oil cost 53½ per cent less than kerosene and 54 per cent less than gasoline, all being used in the same engine under practically identical conditions.

5. The residue from the crude oil was used as a lubricant on ordinary bearings with good effect. The residue also gave good results when used on the streets for laying the dust.

6. Rope belting was not satisfactory in these tests.

7. Large engines when used for pumping purposes should always be provided with friction-clutch pulleys so that they may be started without load.

8. The tests should be continued in order to determine if difficulties will develop with extended use. Arrangements have recently been made to this end.

INTRODUCTION

In a country in which fuel, such as wood and coal, is scarce or high in price, it often becomes necessary to use internal combustion engines for the production of power; that is, engines in which gasoline, naptha, crude oils, etc. are used for fuel.

Some parts of New Mexico are abundantly supplied with wood or coal. In parts not so favored by nature in this respect, these fuels are invariably high in price, a condition which is due in a great measure to the high transportation charges which seem to be unavoidable in a mountainous country. Since New Mexico is a mountainous region, it would seem expedient to use forms of fuel other than wood or coal; those which are not so bulky, and which, therefore, can be more cheaply transported.

Agricultural crops in New Mexico are almost wholly grown by the aid of irrigation and since large areas, which for various reasons cannot be supplied with water by gravity systems, must depend for their development upon irrigation by pumping, cheap fuel is essential. This leads to an inquiry as to which is the cheapest fuel available. It is believed that information regarding the relative value of the different kinds of fuel for the production of power is of the utmost importance. The Agricultural Experiment Station at Mesilla Park has taken up the investigation of the subject as applied, in particular, to pumping water for irrigation from the underflow.

The results of the experiments on this subject so far published are to be found in Bulletin No. 45 of this Station. The tests referred to were made with what later proved to be a poor pump. Nevertheless, the relative fuel values given are probably correct, although the returns for the fuel no doubt ran low; that is, the quantity of water pumped with the consumption of a given amount of fuel was less in this case than it would have been if one of the best pumps had been used. A repetition of the test, using one of the best pumps, will be necessary to determine the maximum return for fuel consumed.

The present bulletin deals with tests of (Beaumont, Texas) crude oil, kerosene, and gasoline when used in a gasoline engine supplied with an attachment for utilizing crude oil and kerosene.

PURPOSES OF THE EXPERIMENT

1. To determine whether (Beaumont, Texas) crude oil can be used successfully as a fuel in an internal combustion engine.
2. To determine the relative value of crude oil, kerosene, and gasoline as fuels for use in an internal combustion engine.

EQUIPMENT

The equipment consisted of a 22 H. P. Fairbanks, Morse & Co's. gasoline engine with a crude oil attachment, and a six-inch centrifugal pump made by the same firm, connected with the engine by an endless rope belt provided with an automatic tightener. This outfit complete was loaned to the Experiment Station by Fairbanks, Morse & Co., Denver, Colorado, for the purpose of making the test.

The pump was placed upon the six-inch Station well which is described in Bulletin No. 45. The engine was placed upon a solid concrete foundation and properly housed.

The Crude Oil Attachment

The crude oil attachment consists of a carburetor made in the form of a small upright boiler set upon legs and connected with the intake and exhaust of the gasoline engine, (see Plate 1). The exhaust from the engine is made to heat the carburetor to the desired temperature, a condition which results in the formation of a gas from the volatile portions of the crude oil. The gas, being lighter than the air, rises to the top of the carburetor from whence it is drawn into the engine. The gas is mixed with more air as it passes the air valve. The residue from the crude oil drops to the bottom of the carburetor and is drawn off. The carburetor is heated either by placing a burner underneath it or by running the engine on gasoline long enough for it to become heated by the exhaust. The temperature of the carburetor, the supply of the crude oil to the carburetor, the supply of the gas from the carburetor to the engine, the amount of air to be mixed

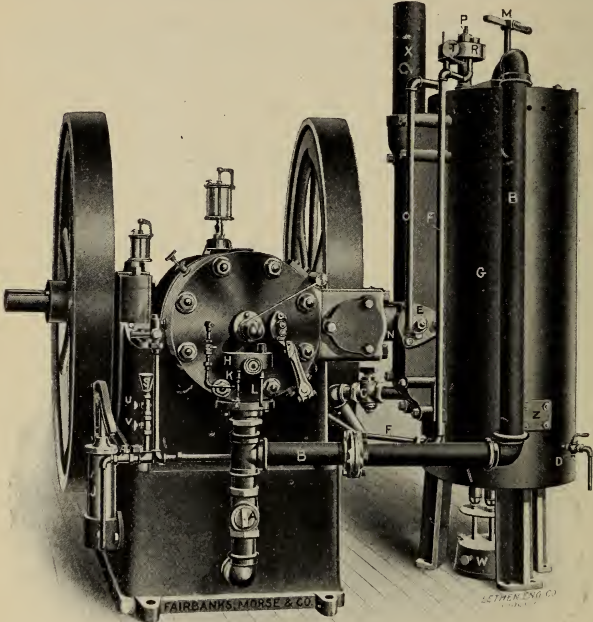

Plate I.—Showing the Crude Oil Attachment.

with the gas, and the quantity of water to be thrown into the gas chamber with the mixture of gas and air, are all regulated by valves. At first, the manipulation of the many valves seemed complicated and difficult, but upon a careful study of the instructions and after repeated trials the adjustment of the valves became simple. After the best position for each valve had been determined and marked, it became an easy matter to make the necessary readjustments in order to conform to the variations of the atmosphere and thus to obtain the greatest amount of power from the oil consumed.

MIXING WATER WITH THE GAS

When running on gasoline the engine did not pound, but when crude oil was used the pounding was marked. However, the makers have provided a way for correcting this difficulty. A small jet of water is thrown into the gas chamber with the gas. This water is drawn from the cooling chamber and requires no extra attachments other than one to connect the water chamber with the gasoline feed. The gasoline feed is not in use when the engine is being run on crude oil, and, therefore, it is free to be used for the purpose named. Practically all of the pounding disappeared with the introduction of the water into the gas chamber. The makers assert that there is no loss of power by this method of preventing the pounding, and the results obtained seemed to indicate that this is true, since the speed of the engine did not noticeably decrease when the water was introduced.

CLOGGING AND GUMMING

So far as could be determined with the length of the test given, there was no clogging or gumming. After running the tests the engine head was removed and the valves and valve seats were carefully examined. There could be found no indications of a deposit of any kind upon the valve seats. It has been suggested that this clean condition may have been due to the fact that the engine each day was run on gasoline long enough to heat the carburetor and this gasoline, which passes the valve in the form of a spray, may have dissolved the deposit, if any was formed, thus keeping the valves clean. If it is proven that the valve seats can be kept clean by the use of gasoline in starting, possible objections on account of clogging in these parts can have very little weight.

COST OF FUEL

The crude oil used in the test was purchased in El Paso, Texas, and shipped by local freight to Mesilla Park. It cost $2.82 per barrel of 50 1-2 gallons, or about 5 3-5 cents per gallon delivered at the Station farm. The kerosene oil was purchased at Las Cruces from the Continental Oil Co., and cost 19 1-5 cents per gallon by the barrel delivered. The gasoline was purchased from the same firm as the kerosene and cost 20 1-5* cents per gallon by the barrel delivered.

WEIGHT OF THE OIL

A given quantity of each kind of oil was carefully measured in a graduate and weighed. The following table shows the weight of one gallon of each kind of oil tested:

Kind of oil	Pounds	Ounces
Crude oil........ . ..	7	9
Kerosene......	6	11-½
Gasoline........... ...	5	15

The quantity of oil consumed by the engine was determined as follows: the tank of oil was weighed before and after each run, and from the difference in the weights and the data given in the above table the quantity of oil used was computed.

In making the tests with crude oil and kerosene, the engine was run on gasoline until the carburetor was heated to the proper temperature, when the engine was transferred to crude oil or kerosene. The amount of gasoline consumed in heating the carburetor and the length of time the engine ran on gasoline were recorded. The cost of the gasoline used in starting each day was included with the cost of running on each kind of oil.

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*Since the tests were made the price of gasoline has dropped to 17 1-5 cents per gallon by the barrel delivered.

ROPE BELTS

During the experiments on the Station farm, a rope belt was used and it gave considerable trouble, resulting in repeated delays in the work. This was no doubt due to the method in which it was used. The rope passed from the engine pulley to a sheaf (grooved pulley for rope belt) at the surface of the ground, from this sheaf around the tightener pulley and back to the same sheaf, down to the pulley on the pump, back to a second sheaf at the surface of the ground, thence back to the engine (see Plate II). Probably no trouble would have been experienced if a counter-shaft had been used and the belt run in two sections, one from the engine to the counter-shaft, and the other from the counter-shaft to the pump.

FRICTION-CLUTCH PULLEY

Whenever a large gasoline engine is used, a friction-clutch pulley should invariably be provided. This permits of starting the engine without load. The load may then be thrown on after the engine is up to speed. The friction-clutch pulley may be placed on the engine shaft, if direct connection is made between the engine and pump; or it may be put on the counter-shaft, if that method of connection is used.

In the experiments made with the 22 H. P. gasoline engine no friction-clutch pulley was provided. The extra load, which consisted of the empty pump, two heavy idler sheaves, and the automatic tightener pulley, had to be handled in starting the engine. It required two men to start the engine with this extra load on, while without this extra load it was found that one man could start it without difficulty.

RESIDUE

The residue that remains after the crude oil is run through the carburetor consists of a thick black oil. This residue was used for some time as a lubricant upon ordinary bearings, such as those on the counter-shaft, with apparently no bad effects. It is quite probable that the residue may be of

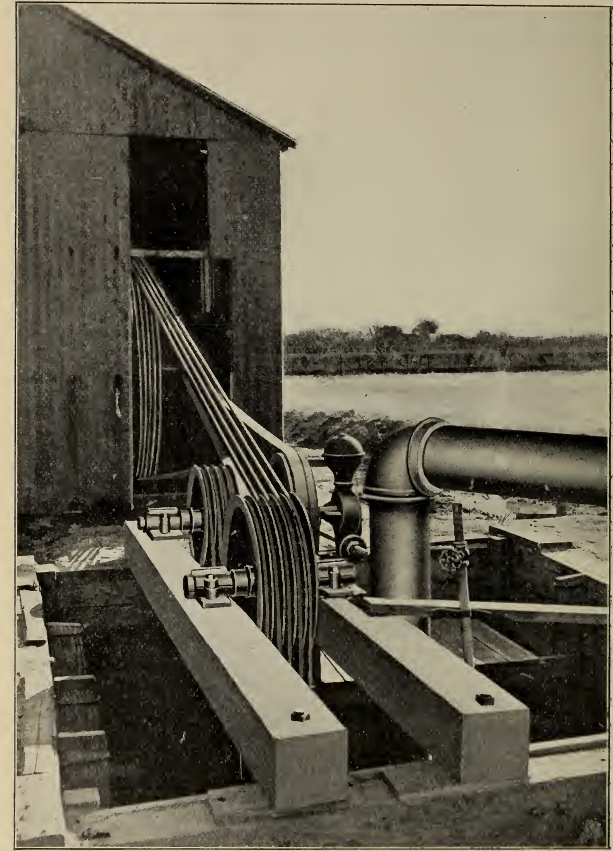

Plate II.—Showing Rope Belt.

considerable value as a lubricant in which case the cost of pumping with crude oil will be materially reduced.

The residue has been shown to be a good dust layer. Two barrels were spread upon a portion of Main Street in Las Cruces, N. M. The one application laid the dust satisfactorily for three or four months.

Probably other uses for the residue may be discovered.

Tables I, II and III show in detail the results of the tests made on crude oil, kerosene and gasoline.

By a comparison of these tables it will be seen that the average lift and the quantity of the water discharged were slightly less, and that there was greater fluctuation in the readings, when crude oil was used than when either kerosene or gasoline was used. This is probably due to the fact that when running on crude oil a readjustment of the air valve must be made at intervals of two or three hours so as to maintain the proper mixture of gas and air. The air is lighter at mid-day than either in the morning or evening, and so the air valve must be opened as the noon hour approaches and then closed somewhat as evening comes on. When running on kerosene or gasoline a change in the position of the air valve was found unnecessary. The foregoing facts, the writers believe, account in part at least, for the slight variation in the readings when running on crude oil.

Table 1—Test on Crude Oil

Showing the results secured in seven runs, using crude oil as fuel.

No.	Length of run hrs. min.	Gallons Crude Oil Consumed	Gallons Crude Oil Consumed per hour	Percent Crude Oil Consumed	Speed Revolutions per minute		Suction	Discharge	Total Lift	Gallons water pumped per minute	Time reading taken
					Engine	Pump	Ft. In.	Ft. In.	Ft. In.		
1	3— 57	18.44	4.66	54	202 199	550 542	23—10 22— 1½	15— 3 15— 3	39— 1 37— 4½	1093 1033	3:45 p. m. 5:50 p. m.
2	8— 30	37.75	4.44	56	203	557	23—10	15— 3	39— 1	1140	9:50 a. m.
3	3— 43	18.77	5.05	50	203	556	24— 5	15— 3	39— 8	1126	5:30 p. m.
4	7— 57	44.82	5.64	43	200 197	547 540	23— 3¼ 22— 8	15— 3 15— 3	38— 6¼ 37—11	1066 1046	1:30 p. m 5:25 p. m.
5	5— 08	23.40	4.56	55	207 201	565 550	25— 3 23— 3¼	15— 3 15— 3	40— 6 38— 6¼	1161 1100	2:10 p. m. 5:10 p. m.
6	7— 53	43.57	5.53	46	207 198	565 544	25— 6 23— 3¼	15— 3 15— 3	40— 9 38— 6¼	1147 1033	2:35 p. m. 5:00 p. m
7	3— 12	19.17	5.99	52	202 194	548 530	23— 3¼ 21— 0	15— 3 15— 3	38— 6¼ 36— 3	1093 1026	3:45 p. m. 5:10 p. m.
Average,			5.12	51	201	549.5	23— 1	15— 3	38— 8	1089	

NOTE—The test was made with the pumping plant described on page five.

NOTE—In all of the tests the quantity of water pumped was determined by measurement with a Cippoletti weir and a hook guage.

Table II—Test on Kerosene

Showing the results secured in two runs, using kerosene as fuel.

No.	Length of run hrs. min.	Gallons kerosene consumed	Gallons kerosene consumed per hour	Per cent kerosene consumed	Speed Revolutions per minute Engine	Pump	Suction Ft. In.	Discharge Ft. In.	Total Lift Ft. In.	Gallons water pumped per minute	Time reading taken
1	7—31				204	558	24—5	15—3	39—8	1119	10:30 a. m.
					204	560	24—5	15—3	39—8	1113	11:30 a. m.
					204	560	24—5	15—3	39—8	1106	12:30 p. m.
					204	562	25—½	15—3	40—3½	1026	1:30 p. m.
					204	563	25—½	15—3	40—3½	1079	2:30 p. m.
					203	557	24—5	15—3	39—8	1048	3:30 p. m.
2	4—6										
	11—37	30.73	3.42	100							
Average			3.42	100	204	560	24—7¼	15—3	39—10¼	1082	

NOTE—The test was made with the pumping plant described on page five.

Table III—Test on Gasoline

Showing the results secured in two runs, using gasoline as fuel.

No.	Length of run hrs min.	Gallons gasoline consumed	Gallons gasoline consumed per hour	Per cent gasoline consumed	Speed revolutions per minute		Suction		Discharge		Total Lift		Gallons water pumped per minute	Time reading taken
					Engine	Pump	Ft.	In.	Ft.	In.	Ft.	In.		
1	3—18				204	558	25—	½	15—	3	40—	3½	1093	10:00 a. m.
2	2—25				203	558	25—	½	15—	3	40—	3½	1099	11:00 a. m.
	5—43	18.82	3.29	100										
Average.			3.29	100	203.5	558	25—	½	15—	3	40—	3½	1096	

NOTE—The test was made with the pumping plant described on page five.

Table IV—Relative Cost of Pumping

Showing the cost of a ten hour and a twenty-four hour run on crude oil, kerosene and gasoline.

	10 Hr. Run	24 Hr. Run
CRUDE OIL.		
30 minute run on gasoline to heat carburetor, 1.64-½ gallons @ 20 1-5 cts....	$ .33	$ .33
9-½ hours run on crude oil, 48.64 gallons @ 5 3-5 cents....................	2.72	
23-½ hours run on crude oil 120.32 gallons @ 5 3-5 cents....................		6.74
Total cost of fuel for running ten hours..............................	$ 3.05	———
Total cost of fuel for running twenty-four hours....................		$ 7.07
KEROSENE.		
30 minute run on gasoline to heat carburetor, 1.64-½ gallons @ 20 1-5 cts...	$ .33	$ .33
9 ½ hours run on kerosene, 32.49 gallons @ 19 1-5 cents....................	6.24	
23-½ hours run on kerosene, 80.37 gallons @ 19 1-5 cents..................		15.43
Total cost of fuel for running ten hours..............................	$ 6.57	———
Total cost of fuel for running twenty-four hours....................		$15.76
GASOLINE.		
10 hours run on gasoline, 32.90 gallons @ 20 1-5 cents..............................	$ 6.65	
24 hours run on gasoline, 78.96 gallons @ 20 1-5 cents..........................		$15.95
Total cost of fuel for running ten hours........................	$ 6.65	———
Total cost of fuel for running twenty-four hours....................		$15.95

Table V—Relative Amount Water Pumped and Acres Irrigated

Showing the average number of gallons pumped per minute, and the acres of land that can be irrigated to a depth of 2, 3, 4, 5 and 6 inches in 10 and 24 hours, when running on crude oil, kerosene and gasoline.

Kind of Oil	Gallons pumped per minute Average	Acres irrigated in 10 hours Inches Deep					Acres irrigated in 24 hours Inches Deep				
		2	3	4	5	6	2	3	4	5	6
Crude Oil	1088	12.02	8.01	6.01	4.81	4.01	28.85	19.23	14.42	11.54	9.62
Kerosene	1082	11.95	7.97	5.98	4.78	3.98	28.69	19.13	14.35	11.48	9.56
Gasoline	1096	12.11	8.07	6.05	4.84	4.04	29.06	19.37	14.53	11.62	9.69

NOTE—The test was made with the pumping plant described on page five.

Table VI—Relative Cost per Acre

Showing the cost of fuel per acre to irrigate to a depth of 2, 3, 4, 5 and 6 inches, when running ten hours each day on crude oil, kerosene and gasoline.

Kind of Oil	Average number of gallons pumped per minute	INCHES DEEP				
		2	3	4	5	6
Crude Oil...............	1088	$ .25	$ .38	$ .51	$ .63	$ .76
Kerosene	1082	.55	.82	1.10	1.37	1.65
Gasoline	1096	.55	.82	1.10	1.37	1.65

NOTE—The test was made with the pumping plant described on page five.

Table VII—Relative Amount and Cost of Fuel

Showing the number of gallons of oil required and the cost of pumping 1, 10 and 24 hours with crude oil, kerosene and gasoline.

KIND OF OIL	Average number of gallons pumped per minute	Gallons consumed in			Cost of running	
		1 hr.	10 hrs.	24 hrs.	10 hrs.	24 hrs.
Crude Oil	1088	5.12	51.2	122.88	3.05*	7.07*
Kerosene	1082	3.42	34.2	82.08	6.57*	15.76*
Gasoline	1096	3.29	32.9	78.96	6.65	15:95

*Including the cost of a thirty minute run on gasoline in order to heat the carburetor.

NOTE—The test was made with the pumping plant described on page five.

THE USE OF CRUDE AND REFINED OILS

In view of the difference in the cost of pumping between crude oil and refined oil (whether kerosene or gasoline) the importance, from a financial standpoint, of the use of the former would seem to impress itself upon those who are seeking to cheapen the cost of pumping. Moreover, the probable discovery of profitable uses for the residue would further lend interest to this important question. If the unconsumed portion of the crude oil, after thorough trial, should prove to be a fair lubricant for ordinary bearings and its use as such were assured, the cost of operating on crude oil would be still further reduced. At an estimated value of 12½c per gallon, the residue thrown out by the carburetor would about equal the original cost of the oil. Furthermore, if the residue were sold for use on streets or roads, at ½c per gallon, the total cost of the fuel for pumping would be reduced by about 4 per cent,—an item in itself not to be ignored. The results obtained show that by the use of crude oil there is a saving, over the cost of pumping with kerosene or gasoline, of 53½ per cent and 54 per cent, respectively, without taking into consideration the value of the residue.

ACKNOWLEDGEMENTS

Acknowledgement is due to the Fairbanks, Morse and Company, Denver, Colorado, for the loan of a 22 H. P. gasoline engine with a crude oil attachment, a No. 6 centrifugal pump, and the necessary fittings complete for setting up the outfit; and to the Atchison, Topeka and Santa Fe Railway for courtesies extended in connection with the experimental work.

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BULLETIN NO. 54

MARCH 1905

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

SOIL MOISTURE INVESTIGATIONS
FOR THE SEASON OF 1904

Soil Moisture Plats Referred to in this Bulletin

BY

J. D. TINSLEY and J. J. VERNON

AUG 1

SANTA FE, N. M.:
THE NEW MEXICAN PRINTING COMPANY.
1905.

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The Bulletins of this Station will be mailed free to Citizens of New Mexico and to others as far as the editions printed will allow on application to the Director

SUMMARY AND CONCLUSIONS

1.—The high wind velocity, very low relative humidity of the air and very small amount of rain during the season caused great evaporation of moisture from the soil and probably exerted an injurious influence on the yield of the wheat, which was only about two thirds of the yield of the previous season.

2.—Irrigating oftener than once in three weeks after wheat begins to head increases the yield, but the increase is scarcely enough to pay for the application of the other irrigations.

3.—Twenty four inches of water gave the greatest yield per inch of water applied; and while 35 and 29 inches of water gave greater yields than did 24 inches, the increase per inch of water is very small. Twenty-four inches was the most economical amount.

4.—There is probably a certain moisture content of the soil, close to 25 per cent. in this soil, necessary for a good growth of straw and yield of grain; and beyond this, wheat is not very sensitive to increase in the moisture content of the soil.

5.—A difference of six inches of water received between the plats of series 1 and 2 was not indicated in the moisture results, but this amount of water gave appreciable differences between the moisture contents of the other series.

6.—Variations in texture and the irregular distribution of the water through the soil make it very difficult to obtain percentages of moisture which will express accurately the true moisture conditions of the soil; but these percentages afford valuable indicationsof the conditions especially in regard to percolation.

7.—The plats as a rule did not gain materially in moisture below the second foot during the season and there were indications of a general loss in total moisture toward the end of the season.

8.—There was no indication of an appreciable loss of moisture from the percolation into the soil below the limits of the roots of the wheat.

INTRODUCTION

This bulletin embraces the results of the cooperative experiments between the Departments of Agriculture and Soils, on Soil Moisture for the season of 1904. The results of previous years were reported in bulletins Nos. 31, 38, 46, and 48 of this station.

The plats were sown to wheat again this season, although they were in wheat the previous year.

The subjects investigated were nearly the same as those studied last season and were:

1.—To learn the effects of different numbers of irrigations on the yield of wheat, especially the effects of different numbers of irrigations applied between the time that the wheat began to head and until it was almost ripe.

2.—The relations between the number of irrigations, the amount of moisture in the soil and the yield.

3.—The relations between the amount of water applied, the soil moisture and the yield.

4.—The distribution of the soil moisture in depth and the amount of percolation.

The Department of Agriculture had charge of the sowing, observations on growth, harvesting, threshing and weighing up the yield. The Department of Soils superintended the irrigating, took the moisture samples and determined the moisture.

Mr. J. M. Scott superintended the work for the Department of Agriculture and Mr. R. H. Hart, student assistant in Soils, rendered valuable assistance in the sampling and moisture determinations.

PLAN OF THE EXPERIMENTS

The results of 1903 indicated that the application of water while wheat was heading and filling was more beneficial than its application before this time, and the experiments this year were designed to test this point further. From the experience of the previous year, it was thought that once a week after the wheat began to head was often enough for the most frequent irrigations. In order to have as many plats as possible in duplicate, it was decided to try irrigating once a week, once in two weeks, and once in three weeks after the wheat began to head.

LOCATION.—The land used for these experiments was that which has been used for the moisture work since 1901.

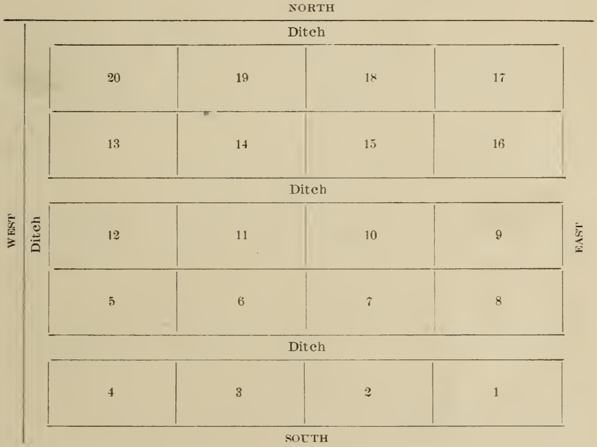
It was decided to decrease the number of plats and make them practically uniform in area. In order to do this, and allow for the necessary borders and ditches, it was necessary to take in some additional land. This was done by adding a strip about fifty feet wide on the north side and one about forty feet wide on the south. This area, about 430 feet east to west by 290 feet north to south, was divided into twenty plats. The area of each plat was approximately one-tenth acre, except the row on the north side in which the plats were slightly larger.

Borders high enough to hold the water used in flooding the plats were thrown up between them.

DITCHES.—The ditches were placed so that each plat could be irrigated independently of the others.

Frames 30 inches long by 12 inches high, with sliding gates, were placed in the sides of the ditches, one to each plat, for letting in the water.

The arrangement of the plats and ditches is shown in the accompanying diagram.



Irrigation.—All of the plats were to be irrigated soon after sowing; again when they were beginning their spring growth, about the middle of April; and for the third time when they began to head, about the middle of May. After this third irrigation plats 2, 6, 9, 12, 13, 17 were to be irrigated once each week; plats 4, 7, 11, 15, 16 and 19 were to be irrigated once in two weeks; and plats 3, 5, 10, 14, 18, and 20 were to be irrigated once in three weeks.

Plats 1 and 8 were higher than the others and therefore difficult to irrigate uniformly; so these were left for trying the effects of a smaller amount of water.

The results of 1903 showed that some parts of this land gave better yields than others; therefore, instead of making up the series from adjacent plats they were made up of alternating plats.

Because of the great variability in the productive capacity of this soil, it is very necessary to have as many repeaters as possible.

MOISTURE DETERMINATIONS

As in the previous season, all of the samples were taken with augers worked through a guard tube. The samples were taken in one foot sections to a depth of six feet. They were taken to that depth in order to find out how far down the irrigating water percolated.

The samples were taken one or two days before irrigation and as soon thereafter as the surface was dry enough to admit walking on, usually five days after the water was applied. This system, of course gave only one sampling to the irrigation on the plats irrigated once a week.

The moisture was determined from the loss in weight on drying at about 110-115 degrees C for several hours.

All the percentages of moisture in this bulletin are expressed in terms of the dry soil. For example, 25 per cent of moisture means that for every 100 parts of dry soil there are 25 parts of water.

SEEDING AND HARVESTING

The ground was plowed and put in condition for seeding early in December, 1903. The same variety of wheat was used as last year,—Algerian White, Station No. 410. This is a bearded variety with large white kernels and heavy straw. It was sown on December 22nd, 1903, at the rate of 2 bushels per acre with a press drill, from 1 1-2 to 2 inches deep, the drills being 8 inches apart. The wheat was harvested with a Champion selfbinder on June 25th. The grain was standing up well over all the field, and, therefore, there was little waste of grain in harvesting.

It was threshed with a three horse-power machine. The machine was cleaned after running through the product of each plat.

IRRIGATION

All of the irrigations were carried out as planned. The first was given on January 5th and was with river water; the second was given on April 19th, this and all succeeding irrigations were with pump water from the Station pumping plant; the third was given on May 18th and after this time they were given once a week, once in two weeks, and once in three weeks according to the schedule until June 15th, when the wheat of all the plats was ripening.

MEASUREMENT OF THE WATER.—The river water for the first irrigation was measured over a two foot trapezoidal (Cippoletti) weir, the depth over the crest of the weir being measured and recorded by a Standard Water Register. The pen of this register moves an inch in an hour and thus measures slight fluctuations in the height in short intervals of time. This weir is located one hundred and ninety yards west of the plats.

For the second and all succeeding irrigations, for which pump water was used, the pump was speeded to throw 1,000 gallons per minute, and this speed was maintained as carefully as possible throughout the run. This water was run over a six foot trapezoidal (Cippoletti) weir (see plate 1) and the depth over the crest was measured with a hook gauge. The gauge was read frequently to see that the flow remained constant. This weir is located about 500 yards from the plats and after the water left it, there was no further check on the quantity. The loss by seepage from the ditch is, therefore, not known; but, so far as we could observe, it was very little.

The area of each of the plats was measured and the time that would be required by a stream of 1,000 gallons per minute to give several depths of water in inches on it was calculated.

The water was allowed to fill the ditch to the height on the gate of each plat at which it stood while flowing into the plat. The gate was then opened and the water allowed to flow in for the cal-

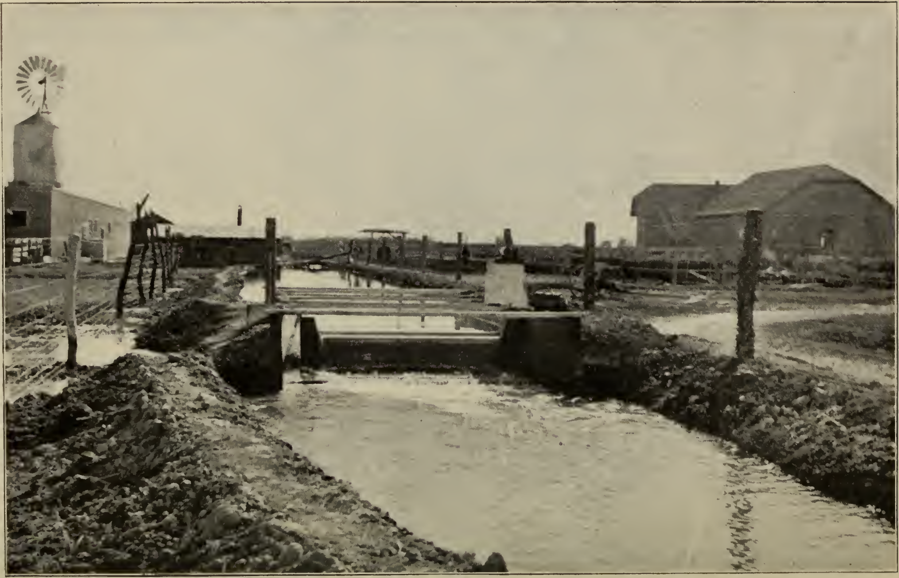


PLATE 1.—Six-foot Cippoletti Weir, with hook gauge on the left and water register on the right

culated length of time. This method is, of course, not extremely accurate but we believe that it gives a fair approximation to the amount of water applied.

AMOUNT OF WATER.—In the first irrigation the plats were flooded according to the judgment of a Mexican irrigator and only the total amount used on all of the plats was calculated. It was assumed that each plat received the same amount. The quantity used was sufficient to flood the entire area of the plats to a depth of six inches.

The depths given in this bulletin are those at which the water would have stood over the given area if none of it had soaked into the ground or evaporated. They do not mean, for example, that the water stood six inches after the plats were irrigated.

Table 1.—Amount of Water Applied.

Depth in Inches.

Date 1904	Irrigated once a week after Heading Plat No. 2	6	9	12	13	17
January 5	6	6	6	6	6	6
April 19	6	6	6	6	6	6
May 18	6	6	6	6	6	6
May 25	5	5	5	5	5	5
June 2	4	4	4	4	4	6
June 8	4	4	4	4	4	4
June 15	4	4	4	4	4	4
Total	35	35	35	35	35	37

Date 1904	Irrigated once in two weeks after Heading. Plat No. 4	7	11	15	16	19
January 5	6	6	6	6	6	6
April 19	6	6	6	6	6	6
May 18	6	6	6	6	6	6
June 2	6	6	6	6	6	6
June 15	5	5	6	5	5	5
Total	29	29	30	29	29	29

Table 1.—Amount of Water Applied.—Continued.

Irrigated once in three weeks after Heading.

Date 1904	Plat No. 3	5	10	14	18	20
January 5	6	6	6	6	6	6
April 19	6	6	6	6	6	6
May 18	6	6	6	6	6	6
June 8	6	6	6	6	6	6
Total	24	24	24	24	24	24

Depth in Inches.

Not Irrigated during Heading.

Date 1904	Plat No. 1		8
January 5	6		6
April 19	6		6
May 19	6		6
Total	18		18

Table 1 gives the dates of the irrigations and the depths of water given at each.

Plat 17, 18, or 19 was irrigated first each time and the amount of water necessary to flood it well all over was used on each of the other plats in the series, with two exceptions. On June 2nd, 6 inches were required to wet plat 17 well, while 4 inches were sufficient for the other plats of this series. On June 15th, plat 11 was given an additional inch by mistake.

The second irrigation of plat 17 may be taken as an illustration of the method of finding out the amount of water necessary for the irrigation of a plat. When 3 inches had run in, the water had gone over less than half of the plat; another inch was added and this (4 inches) did not get entirely over, so another was added, and the five inches barely wet the highest places; another inch was then added making six inches in all. This amount was then given to each of the other plats of this series, and on those on the south side, the water stood 3 or 4 inches deep in the lower places.

The surface of the soil of all of the plats was considerably cracked from before the time of the second irrigation until the end of the season. The size of the cracks varied with the texture of the soil. The south side of the area is clay loam to light clay and the cracks here were not so large nor so deep as on the north side which is clay to heavy clay.

Plate 2, from a similar soil planted to alfalfa, gives a good idea of the cracks in the north row of the plats. The rule is six inches long.

These cracks allow the water to get down into this heavy soil and wet it more readily than if it had to percolate through an unbroken surface. On the other hand, they tend to make the distribution of the water uneven.

METEOROLOGICAL CONDITIONS OF THE SEASON

In the following table will be found the mean temperature, mean relative humidity, average wind velocity per hour and amount of rain for each month from the time that the wheat was sown until it was cut. In order to bring out more clearly the conditions which prevailed during the season, the averages for the same months of the six preceding years are given.

The mean temperatures were obtained by taking the average of the maximum and minimum temperatures for each day of the month and averaging these.

By relative humidity is meant the percentage of moisture present of the total amount that the air could hold at that temperature. For example, if the relative humidity of the air is 50 per cent. that means that there is only one half as much moisture in the air at that time as there would be if the air contained all of the moisture that it could hold at that temperature. The percentages of relative humidity are the mean of the morning and evening observations for each day averaged for each month.

The wind velocities were obtained by dividing the total wind movement in miles for each month by the number of hours in the month.

The rain is the average of the total rainfall for each month.

The rate of evaporation from the surface of the soil, or from a water surface, depends upon the wind velocity, relative humidity of the air and temperature. At the ordinary temperatures of the growing season the rate of evaporation is probably influenced most

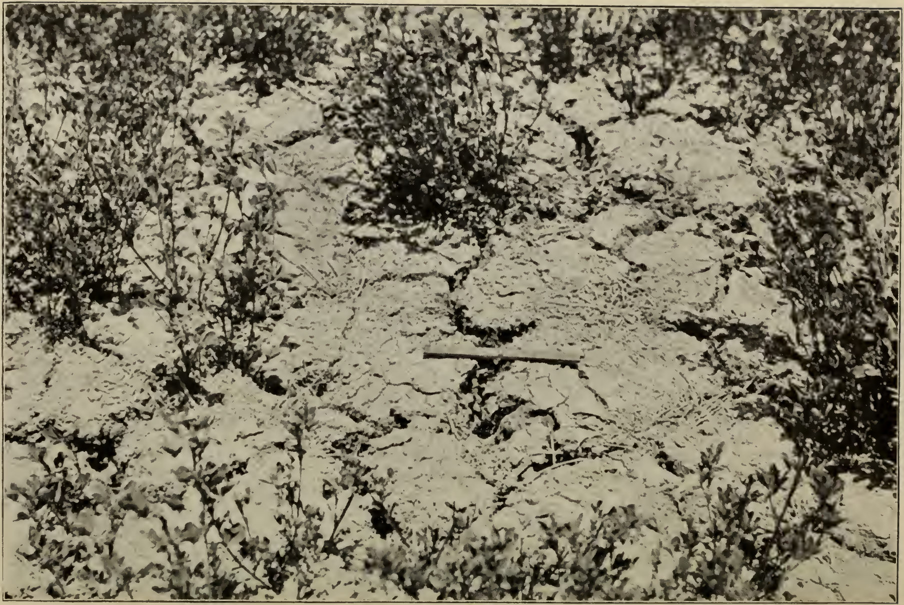


PLATE 2.—Cracks in a heavy clay (adobe) soil.

by the wind and increases rapidly with increased wind velocity. Relative humidity is also a very important factor since the drier the air, lower the relative humidity, the more rapid will be the evaporation.

Table 2.—Meteorological Data

	Mean Temperature. F°		Relative Humidity, Mean. Per Cent.		Wind Velocity Av. Miles per hour.		Rain	
	1898–1903	1904	1898–1903	1904	1898–1903	1904	1897–1903	1904
January	41.5	37.8	47.0	23.0	6.1	6.9	.20	.00
February	44.8	48.0	45.3	25.3	8.0	7.3	.45	.11
March	50.9	55.9	38.5	14.1	9.3	10.0	.46	.00
April	58.5	57.5	35.3	13.3	9.3	9.9	.25	.00
May	66.1	68.0	36.9	18.0	8.7	9.5	.16	.05
June	74.7	76.9	38.0	25.1	7.3	9.9	1.24	.70
Average for season	56.1	57.4	40.1	19.8	8.1	8.9	*2.76	*.86

*Total instead of average.

In the following table the average mean temperature, relative humidity, wind velocity and total rainfall are given for January to June inclusive, for each year together with the final averages for comparison with the conditions of 1904.

Table 3.—Meteorological Data.

Year................	1898	1899	1900	1901	1902	1903	Average	1904
Mean Temperature	54.7	53.6	58.0	57.1	58.0	55.0	56.1	57.4
Relative Humidity..	60.8	48.3	42.8	30.6	22.0	36.3	40.1	19.8
Wind, Av. vel. p. hr.	7.1	7.8	8.2	8.6	8.3	8.5	8.1	8.9
Rain, Total..........	3.25	1.25	3.46	3.20	.20	5.22	2.76	.86

These tables show that the conditions were more favorable to evaporation during this season than they were in any of the six preceding years.

There were two years, 1900 and 1902, with a slightly higher

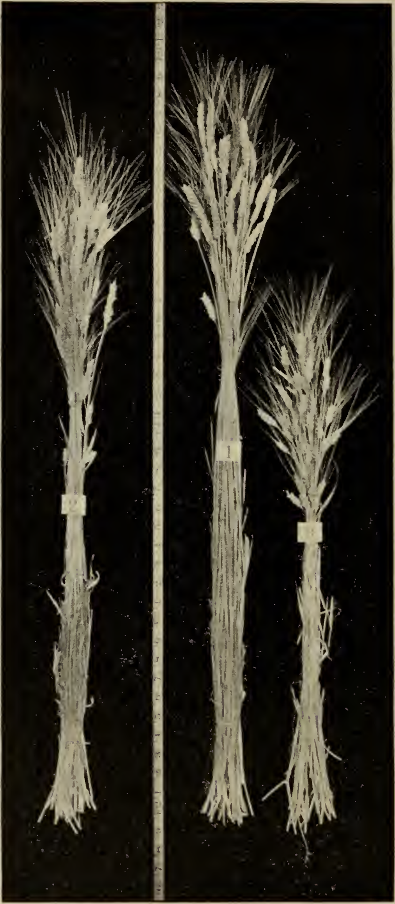


PLATE 3.—Samples showing the average best (No. 1), average (No. 2), and average poorest (No. 3) of the wheat.

mean temperature but in 1904 the temperature was above the average.

The relative humidity was much lower than in any year except 1902 and was only half the average.

The average hourly velocity of the wind was higher than in any of the preceding years and was nearly a mile an hour above the average. While there were fewer storms than usual during this period in 1904, the wind maintained a more constant high velocity as is shown by the high average for each month.

The rainfall was much less than in any year except 1902, being about half that of 1899, and less than one third of the average. Of the .70 inch of rain in June, .55 inch fell after the wheat was cut and exerted no influence on the crop; but as the moisture samples of the last sampling were not taken until a few days after the rain, it may have increased the moisture content of the samples by a slight amount. The amount of rain during the season was so small that it has not been considered in the discussions of the amounts of water received by the crop.

These conditions not only caused a great loss of moisture from the soil but they also probably exerted an injurions action on the growth and yield of the wheat. The yields per acre for this season are only about two thirds of those of the previous year and that this decrease is probably not altogether due to soil conditions is indicated by the fact that other experimental plats of wheat on the station farm gave yields that were 10 to 20 per cent. less than the yields of the same varieties in 1903.

NOTES ON THE CONDITION OF THE CROP

The following notes show the general condition of the crop during the growing season.

April 1.—Good even stand on all of the plats. Rabbits pasturing on plats 1 to 8 but this will probably not affect the wheat materially.

May 2.—No apparent difference in the wheat on the various plats. Effect of the rabbits practically overcome.

May 25.—All plats heading and some heads beginning to bloom.

June 1.—Beginning to fill.

June 8.—Grain almost full size—watery stage.

June 15.—Grain full size—milk stage.

June 22.—Grain dough stage—taking on lighter color—beginning to ripen.

Plate 3 shows three samples of the wheat cut off close to the ground, taken at the time of harvesting. No. 1 is the average of the tallest on the plats and was about 4 feet 2 inches high. No. 2 was about the average height of the best, which was about 3 feet 6 inches. No. 3 was an average of the poorest on any of the plats and was about 2 feet 10 inches high.

The tallest of all was on a portion of plat 9 and this was about 4 feet 10 inches high.

EFFECT ON THE YIELD, OF DIFFERENT NUMBERS OF IRRIGATIONS AFTER WHEAT BEGINS TO HEAD.

In table 4 the plats are arranged in series according to the frequency of irrigations. The yields of grain are calculated from the weights to bushels per acre (60 lbs. equal 1 bushel) and the straw to pounds per acre.

For the sake of brevity the plats irrigated once a week after heading will be referred to as series 1; those irrigated once in two weeks, as series 2; those irrigated once in three weeks, as series 3; and those not irrigated after it began to head, as series 4.

The highest yield of grain (25.8 bu.) is found in series 1 and the lowest (8.8 bu.) in series 4. One of the lowest (13.2 bu.) is found in series 1 and two high yields in series 2. Series 1 averages 1.4 bu. more than series 2. This average is, however, raised materially by the high yield of plat 17. If we exclude plat 17 the average for series 1 falls to 16.5 bu., a little below that of series 2.

Series 1 and 2 average higher than series 3, but four of the plats in series 3 average nearly as high (16.3 bu.) as either series 1 or 2; and if plat 20 is excluded, the average for series 3 rises to 15.7 bu. The reason for excluding plat 20 is that the surface soil is very heavy and its mechanical condition is such that very little water went below the surface foot. In this respect it differed from all of the other plats.

Series 4 averages considerably below the others, yet plat 20 yielded less than plat 8.

Excluding plat 17 from series 1 and plat 20 from series 3, the yields are as follows: Series 2, 16.6 bu.; series 1, 16.5 bu.; series 3, 15.7 bu.; and series 4, 10.6 bu.

These results lead to the conclusion that on these plats there is no decided advantage in irrigating oftener than once in three weeks after the wheat begins to head.

Table 4.—Number of Irrigations, Amount of Water, Moisture Content and Yield.

Plat Number.	Yield		Average Percentage of Moisture in				Depth of water applied in inches
	Grain, Bushels per Acre	Straw, Pounds per Acre	2 feet	3 feet	4 feet	6 feet	
Irrigated once a week after heading.							
2	17.5	1898	24.7	22.8	20.1	14.7	35
6	14.9	1315	25.8	24.2	22.9	17.6	35
9	19.5	3645	27.7	24.9	23.9	18.1	35
12	13.2	1368	24.4	22.1	19.9	14.8	35
13	17.2	1818	25.0	20.9	17.7	13.1	35
17	25.8	1640	31.4	29.1	27.2	20.0	37
Average	18.0	1947	26.5	24.0	21.9	16.4	35.3
Irrigated once in two weeks after heading.							
4	14.3	1506	28.5	27.4	26.4	19.9	29
7	16.6	1540	21.6	20.0	18.6	14.6	29
11	14.1	1251	24.8	22.3	21.3	16.3	30
15	21.2	2430	28.5	24.4	21.8	16.7	29
16	20.0	3280	29.0	25.3	23.3	18.5	29
19	13.8	1400	28.8	25.3	21.9	16.1	29
Average	16.6	1901	26.9	24.1	22.2	17.0	29.2
Irrigated once in three weeks after heading.							
3	16.5	1953	26.4	23.9	22.2	17.7	24
5	16.4	1517	24.8	21.4	20.9	16.6	24
10	13.6	1203	23.9	21.1	18.0	13.9	24
14	16.2	1421	26.2	23.5	19.7	14.5	24
18	16.0	1561	29.3	26.0	21.7	15.6	24
20	11.7	1045	20.1	17.3	15.1	11.3	24
Average	15.1	1450	25.1	22.2	19.6	14.9	24
Not Irrigated after heading.							
1	8.8	993	18.9	17.2	15.6	11.6	18
8	12.5	1421	23.6	20.5	17.9	14.5	18
Average	10.6	1207	21.2	18.9	16.8	13.1	18

RELATIONS BETWEEN THE NUMBER OF IRRIGATIONS, SOIL MOISTURE AND YIELD.

In table 4, in addition to the yields, the average percentages of moisture for the season in each plat are given, not only for the first two feet, as in Bul. 48, but for the first three, first four, and first six feet of the soil.

Plat 17 with the highest percentage of moisture (31.4) gave the highest yield and plat 1 with the lowest (18.9) gave the lowest yield. Plats 15 and 16 with 28.5 and 29.0 per cent. also gave high yields while plat 19 with 28.8 per cent. gave one of the lowest yields.

In considering the individual plats we fail to find any close relation between the amount of soil moisture and the yield.

Taking the averages of the series, we find series 1 with a little less moisture than series 2 and a slightly greater yield and series 3 with slightly less moisture and a smaller yield than either 1 or 2. If we again exclude plats 17 and 20 from this series, the moisture content and yields stand as follows: Series 2, average percentage of moisture in first two feet 26.9, average yield 16.6 bu.; series 1, moisture 25.5 per cent., yield 16.3 bu.; series 3, moisture 26.1 per cent., yield 15.7 bu.; and series 4, moisture 21.2 per cent., yield 10.6 bu. The results for series 3 are irregular and we have to conclude that there is little if any correspondence between soil moisture and yield within narrow limits of moisture.

Table 5.—Yield, Moisture Content and Amount of Water. Plats Grouped According to Yield.

Yield		Average percentage of moisture in				Depth of water applied in in inches
Grain Bushels Per Acre	Straw Pounds Per Acre	2 feet	3 feet	4 feet	6 feet	
Group 1.—Yield 25 — 26 bushels per acre. Plat 17.						
Average 25.8	1640	31.4	29.1	27.2	20.0	37
Group 2.—Yield 19 — 22 bu. per acre. Plats 9, 15, and 16.						
Average 20.2	3118	28.4	24.9	23.0	17.8	31
Group 3.—Yield 16 — 18 bu. per acre. Plats 2, 3, 5, 13. 14, and 18.						
Average 16.6	1673	25.4	22.6	20.1	15.2	28
Group 4.—Yield 13 — 15 bu. per acre Plat 4, 6, 10, 11. 12, and 19.						
Average 14.0	1340	26.0	23.7	21.7	16.4	30.3
Group 5.—Yield 8 — 12.5 bu. per acre. Plats 1, 8, and 20.						
Average 11	1153	20.8	18.3	16.2	12.5	20

In table 5 the plats have been divided into five groups according to their yields, and the average yield, average moisture content of the different depths, and average depth of water applied are given for each group.

The yields decrease with the amount of moisture, except group 4 which though having a little more moisture than group 3, has a yield of 2.4 bu. less.

These results tend to verify the conclusion that the yield does not correspond closely with the amount of moisture.

In tables 4 and 5 the yields of straw are found to agree with the yields of grain rather than with the amount of moisture, except for plat 17 where the amount of straw is small in proportion to that of grain.

On comparing the yields of the plats of 1903 with the yields of those occupying practically the same ground this year, it is found that the soil which gave the best yields the previous year also gave the best this season, and the poorest last season, the poorest this. These results tend to confirm the conclusions drawn last season "that for wheat the yield is more intimately connected with other factors than with soil moisture."

RELATIONS BETWEEN THE AMOUNT OF WATER APPLIED, SOIL MOISTURE AND YIELD.

On comparing series 1 and 2, table 4, it is found that 29.2 inches of water gave .4 per cent. more moisture in the first two feet of the soil of series 2 than did 35.3 inches for series 1, and series 2 shows more moisture at each depth than series 1. Series 3 received 5.2 inches less water than series 2 and shows 1.8 per cent. less moisture in the first two feet and also less at the other depths.

If we omit plats 17 and 20 from the averages of their series the differences are greater. Then series 1 which received 35 inches of water had 25.5 per cent. of moisture; series 2, 29.2 inches of water, 26.9 per cent. moisture; series 3, 24 inches of water, 26.1 per cent. of moisture. Twenty-four inches of water on series 3 gave .8 per cent. less moisture than 29.2 in. of water on series 2 and .6 per cent. more moisture than 35 in. on series 1.

Considering the yield, omitting plats 17 and 20, 24 in. water gave .6 bu. less than 35 in. and .9 bu. less than 29.2 in. Taking the yields as given in table 2, including plats 17 and 20, we find that

24 in. water gave 1.5 bu. less than 29.2 in. and 2.9 bu. less than 35.3 in.

Series 4 is scarcely comparable with the others as the lay of the land made the distribution of the water very irregular, and it is doubtful if one sample for each of these plats represents a fair average. Taking the results found for this series, they received 6 inches of water less than series 3, containing 3.9 per cent. less moisture and yielded 4.5 bu. less of grain.

The variations in the yields relative to the amount of water used are further emphasized in the following table in which the yields in bu. per acre for 1 inch of water are given. The numbers were obtained by dividing the yield of each plat by the number of inches of water used on that plat.

Table 6.—Yield in bu. per Acre of Grain for 1 Inch of Water.

Series 1.		Series 2.		Series 3.		Series 4.	
Plat	Bu.	Plat	Bu.	Plat	Bu.	Plat	Bu.
2	.50	4	.49	3	.69	1	.49
6	.43	7	.57	5	.68	8	.70
9	.56	11	.47	10	.57		
12	.38	15	.73	14	.68		
13	.49	16	.69	18	.67		
17	.70	19	.48	20	.49		
Av.	.51	Av.	.57	Av.	.63	Av.	.59

Series 3 is the most uniform, if plat 20 is omitted, and gave the highest average yield. Series 4 comes next in average yield but there is a great difference between the yields of the two plats. Plat 8 gave as high a yield for the water used as plat 17 of series 1 although the actual yield of plat 17 was about twice as great as that of plat 8. Series 2 gave the next highest average yield but there is much variation between the yields of the plats. Plat 15 of this series gave the highest yield per inch of water of any of the plats but its actual yield was 4.6 bu. less than that of plat 17. Series 1 gave the lowest yield per inch of water and has the greatest variation among its plats. Plat 12 gave the lowest and plat 17 the highest yield of all.

Series 1 Illustrates very clearly the great differences which may occur in the yields from soils which receive practically the same amount of water and further emphasizes the fact that the soil moisture is only one of the factors influencing the yield of crops.

The increase in yield for this season for the amount of water used above 24 inches would scarcely have paid for the cost of the extra irrigations if river water had been used and it would have been produced at a loss if the water had been pumped.

The question naturally suggests itself, why did not the six inches more of water applied to series 1 than to series 2 raise the moisture content of series 1 above that of series 2? There may be several reasons for this.

The first reason lies in the irregular distribution of the water over the plats in irrigating. It is practically impossible when working under field conditions to make the surface of the plats uniform and. of course, the lowest places receive the most water. Then, too, inequalities in the texture and mechanical condition of the soil cause the water to be absorbed irregularly, making some spots more moist than others. These irregularities in texture and mechanical condition also influence capillarity or the rate at which water moves to the surface to supply that lost by evaporation. Irregular distribution of the roots of the crop, taking more water from some spots than others may have an influence on the distribution of the moisture. These are some of the reasons why certain spots in a plat are more moist than others.

The time that can be devoted to these experiments makes it practically impossible to take more than one six foot sample from each of these plats at the time of sampling. This sample is taken to represent as nearly an average as the person sampling can judge; it is usually taken from near the center of the plat, but there are many chances against this sample being an absolute average. These errors are partially eliminated in averaging the results for each plat for the season, as the moisture content of any single sample is probably as likely to be above the average as below it, and are further reduced in the final average for the series of plats.

Another reason lies in the variations in texture and mechanical condition of the different plats. The capacity of the soil of some of the plats to absorb water is considerably greater than that of others.

Still another reason is to be found in the amount of water applied at an irrigation. In series 2 and 3 six inches of water was applied each time, with one exception, while in series 1 the fourth irrigation was 5 inches and the last three 4 inches.

Previous experiments made here have shown that the rate of loss of water from the upper six inches of a soil is proportional to the amount of water present. For example, a fairly saturated soil containing 48 per cent. of moisture will lose 12 per cent., one fourth, of its moisture more rapidly than it loses the next 12 per cent. This being true, the plats receiving the lighter and more frequent irrigations would lose by evaporation a greater percentage of the water applied than would those receiving the heavier and less frequent irrigations which went deeper into the soil.

Other experiments now in progress on the irrigation of alfalfa tend to confirm the idea that less frequent heavy irrigations, for fairly deep rooted crops, are more economical both in soil moisture and cost than are more frequent light ones.

The evaporation from the surface of wet soil was exceptionally great this season because of an unusually large number of high, dry winds.

All of the plats would have shown higher average percentages of moisture if they had been sampled sooner after irrigation, and this difference would have been most marked in the averages of series 1 where it would probably have amounted to 2 or 3 per cent. and brought the moisture content of this series above that of the others.

These numbers must not be taken too literally, for it is here, that the unequal distribution of the moisture and the influence of the texture are most marked in their effect on the numerical results. For example, some sets of samples showed that those taken after irrigation were from spots that must have been very much drier before irrigation than the spots from which the samples before irrigation were actually taken. Again, where a one-foot sample passed through two layers of different texture, one layer loam and the other sand, more of the heavy material was included in one sample than in another and because of this one showed a higher moisture content than the other.

CHANGES IN MOISTURE CONTENT AT DIFFERENT DEPTHS DUE TO PERCOLATION AND CAPILLARITY

In the following table an attempt has been made at showing the movement of the moisture down through the soil. The movement depends mainly upon the texture of the soil as this controls the amount of water held by the soil as well as the rate at which the water moves through it. Heavy clay holds the greatest percentage of moisture per unit volume or weight and it allows water to pass through it most slowly because of the minuteness of the spaces between its small grains. Loams on the other hand are composed of much larger grains, have much larger spaces between the grains and therefore allow water to pass through them much more readily than do the clays. The total amount of pore space in clays is greater than that in loams, although the pores in the loams are the larger; and this together with the fact that the total area of the grains in a given volume or weight of clay is much greater than the total area of the grains in the same volume or weight of loam, explains why clays can hold so much more moisture than loams, Loams hold more moisture and allow it to pass through them less freely than do sands, for the above stated reasons.

Because of the close relations between texture and moisture content the texture of each foot is given in the table. The names of the textures have been abbreviated and the following symbols are used: Clay, C; clay loam, SCC; loam, SC; sandy loam, SSC; sand, S; h in a symbol means heavy, e. g. SCCh means heavy clay loam; the plus sign shows that material of both textures is found in that foot.

The numbers in this table have been obtained by taking the average of the percentages of moisture in each foot before irrigation and subtracting them from the average percentages found in each foot after irrigation. The — sign before a number indicates that the average amount of moisture found before irrigation was greater than that found after irrigation.

Table 7.—Average Gain or Loss in Moisture During the Season.

Depth.	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Texture	Moisture per cent.	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Average.
Irrigated once a week after heading. Received 35 inches of water, except plat 17 which had 37 inches.													
	Plat 2		Plat 6		Plat 9		Plat 12		Plat 13		Plat 17		
1st ft.	SCCH	11.2	C	11.7	C	13.3	C	11.6	C	11.6	Ch	11.6	11.9
2nd ft.	SCC	2.6	C	3.5	C	5.7	SCC	5.1	C	5.1	Ch	4.2	4.4
3rd ft.	SC	-2.4	SCh	0.2	SCC	0.0	SC	1.4	SC	1.4	SCC	-1.2	-0.1
4th ft.	SC+S	-1.0	SC	1.9	SCC	-3.4	SC+S	2.4	SC	2.4	SC	-0.1	0.6
5th ft.	S	1.2	S	-0.6	SCC+S	-0.3	S	0.7	S	0.7	SC+S	0.7	0.7
6th ft.	S	0.2	S	-0.1	S	-0.6	S	0.4	S	0.4	S	1.6	0.4
Average		2.0		2.7		2.5		4.2		3.6		2.8	3.0
Irrigated once in two weeks after heading. Received 29 inches of water, except plat 11 which had 30 inches.													
	Plat 4		Plat 7		Plat 11		Plat 15		Plat 16		Plat 19		
1st ft.	C	13.7	C	10.2	SCCh	10.7	C	13.5	C	12.2	Ch	12.0	12.1
2nd ft.	Ch	4.8	SCC	5.9	SCC	6.3	C	4.2	C	4.1	Ch	2.6	4.7
3rd ft.	SCC	2.7	SC	3.4	SC	3.1	SCC+SC	3.7	SC	2.8	C	-0.5	2.5
4th ft.	SCC+SSC	-0.4	SC	-1.8	SC	4.6	SCh	2.7	SC	3.1	SCC	1.5	2.0
5th ft.	SSC	-1.1	S	-0.5	S	1.1	SC+S	0.6	SC+S	1.7	S	-0.3	0.7
6th ft.	S	1.1	S	-0.3	S	1.1	S	0.0	S	0.8	S	-0.1	0.4
Average		3.5		2.8		5.0		4.1		4.1		2.5	3.7
Irrigated once in three weeks after heading. Received 24 inches of water.													
	Plat 3		Plat 5		Plat 10		Plat 14		Plat 18		Plat 20		
1st ft.	C	13.2	C	14.7	C	14.1	C	17.7	Ch	14.9	Ch	15.9	15.1
2nd ft.	C	3.0	C	5.8	C	6.0	C	6.7	Ch	8.9	SCh	7.9	6.4
3rd ft.	SC	6.7	SC	2.8	SCh	3.2	SCh	2.3	C	3.4	SC	-0.6	3.0
4th ft.	SC	5.1	SC	1.7	SSC	2.5	SC+S	1.6	SCC	0.0	SC+S	2.8	2.3
5th ft.	SSC	2.1	S	4.2	S	0.9	S	0.6	S	-0.8	S	0.3	1.2
6th ft.	S	1.2	S	1.2	S	0.9	S	0.7	S	-0.1	S	-0.7	0.5
Average		5.2		5.1		4.6		4.9		4.4		4.3	4.7

Table 7.—Average Gain or Loss in Moisture During the Season—Continued.

Depth	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Texture.	Moisture per cent.	Average.
Not Irrigated after heading. Received 18 inches of water													
	Plat 1		Plat 8										
1st ft.	SCCh	17.1	SCCH	17.6									17.4
2nd ft.	SCCh	6.4	SCCH	6.1									6.3
3rd ft.	SC	4.5	SC	0.7									2.6
4th ft.	S	1.7	SC—S	0.5									1.1
5th ft.	S	2.3	S	2.5									2.4
6th ft.	S	0.6	S	2.5									1.6
Average		5.4		5.0									5.2

From this table it will be seen that the texture is very unfavorable to the economical use of water because of the favorable conditions for the rapid loss of water by evaporation. The texture of the first and second feet is clay loam to clay and this prevents the water from percolating quickly to the lower layers. The water being held close to the surface for a considerable length of time is exposed to more favorable conditions for evaporation and the loss is probably much greater than it would be if the water penetrated more deeply into the soil and was brought back to the surface by capillarity. This retention of the water near the surface was very marked after the first irrigation, in January, at which time the surface soil was very loose from the recent cultivation. The upper half of the first foot of the soil was then saturated and very miry while the lower half was quite stiff. Plats 19 and 20 have the heaviest and most impervious surface foot; although plats 17 and 18 are nearly as heavy, and at the time of the first irrigation the water was held so completely in the plowed portion of the first foot that four days after irrigation when a hole was bored, the water drained out of this surface portion into the hole. It was seven days before enough of the water had soaked in, or evaporated from the surface, to permit of samples being taken without this drainage. The lowest spots on these plats, which therefore received the most water, required two or three days for the standing water to disappear from the surface.

The plats on which the first two feet is clay loam allowed the water to percolate more rapidly and on some of these the standing water had disappeared within twelve hours. This was a six inch irrigation. Later in the season when the soil had settled and cracked, the water penetrated the heavier soils rather more rapidly.

TEXTURE.—On comparing the textures of the first two feet of the four series of plats, it is found that while the textures on the different plats vary, the averages for the first three series are fairly similar; series three has slightly the heavier, while series four is lighter than the others.

The textures of the third, fourth, and fifth feet are quite variable, so much so, that it is difficult to compare them. The sixth foot is in all cases sand.

MOISTURE.—The total average gain in moisture for each series increases from 3.0 per cent. in series one which received the most frequent irrigations and greatest amount of water, to 5.2 per cent. in series four which received the fewest number of irrigations and least water.

An increasing gain, such as is found in the averages of the first foot for each series, would be expected, and such gain might be expected in the second, and, possibly, in the third foot because these gains would be due to the fact that, in the series which received the fewest number of irrigations, the soil would lose the greatest amount of moisture between the irrigations and therefore the differences between the amounts of moisture present after irrigation and those present before would be greatest; but it is scarcely to be exexpected that these changes would affect the fourth to sixth feet to the extent shown by these figures. It would be expected that the fourth to sixth feet would show an increase in moisture on the plats that received the greatest amount of water, provided that they received more water than was necessary to supply the loss from evaporation and the water used by the plants, after the first three feet had had their moisture content raised to the point where they would admit of some of their water passing down by capillarity at least if not by percolation. The increase in moisture content at these depths on the plats of series one is not as much as would be expected from capillary movement and shows practically no signs of percolation.

The results shown by the figures lead to the conclusion that below the second foot there was little gain in moisture in any of the series of plats. The most of the gains shown are within the limits of error of sampling, i. e. the amounts shown are not greater than the difference in moisture content between two samples taken at the same depth from places a few feet apart on the same plat.

An examination of the detailed data for each plat shows that, after making allowances for the prominent variations between samples taken before and after the same irrigation, there was no marked increase of moisture below the third foot; and, further, that even the series of plats that received 35 inches of water contained on the whole rather less moisture at the close of the season than they did after the first irrigation.

The results show conclusively that none of the water applied to the plats reached the water table which lies at about 14 feet from the surface of the land; or in other words, that there was practically no loss from seepage and that probably very little of the water passed below the limits of the roots of the wheat.

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New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION
MESILLA PARK, N. M.

TUBERCULOSIS IN CATTLE
AND
Tuberculin Tests of the Station Herd.

BY
JOHN M. SCOTT.

SANTA FE, N. M.:
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1905.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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The Bulletins of this Station will be mailed free to Citizens of New Mexico and to others as far as the editions printed will allow on application to the Director.

SUMMARY

1. Bovine tuberculosis is known to be infectious, and it is general throughout the United States.

2. The agents for carrying and spreading tubercular germs are many; such as food, feed racks, salt boxes, watering tanks, etc.

3. Since a physical examination is not sufficient to diagnose a case as tubercular, some other test must be used, and the tuberculin test has proven to be the most reliable, but great care is necessary in making the test.

4. Some experiments show that the use of milk from tubercular cows, whether the udder be affected or not, will cause tuberculosis.

5. The following preventative measures may be taken to assist in retarding the progress of the disease and which will tend to eradicate it after having secured a foothold: All breeding animals brought into the Territory should be subjected to the tuberculin test, all suspected herds should be tested at least once a year, and all reacting animals should be slaughtered and the carcass either buried or burned.

6. All reacting animals in the Station herd, 15.8 per cent, upon post-mortem examination were found to be tubercular.

7. The tests made, on the Station herd, show that tuberculosis exists in New Mexico.

INTRODUCTION

At the present time authorities still differ as to whether human and bovine tuberculosis are caused by the same bacilli or by entirely different bacilli, but the weight of opinion is that bovine tuberculosis can and is transmitted to children by the use of milk from tubercular animals; therefore, it is, perhaps, much safer for the consumer to take the necessary precautions against infection until authorities come to an agreement on the subject.

It is not the purpose of the writer to enter into a discussion of this much-debated question. Until authorities agree upon the subject, it is much safer to consider that Human and Bovine tuberculosis are caused by the same germ, and that the disease is transmissable from one to the other, and for the purpose of this bulletin they are so considered.

TUBERCULOSIS

We may define tuberculosis as a communicable disease due to the presence of microscopical plant parasites in the animal body. These parasites, or germs as they are called, cause the formation of hard, knotty bunches called tubercules, which vary in size from that of a pin head to that of a walnut, and often larger. When these tubercules are cut open with a knife a gritty feeling or sensation is produced very much the same as when a knife is cutting through sand. This is one of the best ways, in the post-mortem, to diagnose the disease as tuberculosis.

Tuberculosis is known by a variety of names. It is called "lupus" if confined to the skin only; by the Greeks it is called "phthisis," meaning in their language "wasting" or "consumption."

Perhaps there is no disease which has been more thoroughly discussed during the past ten years than tuberculosis; discussed from all points of view, through the agency of the press and from the platform. But notwithstanding all that has been written and said on the subject, still many people are very indifferent and negligent in their efforts to retard or eradicate this dreadful malady. Two principal reasons may be given for taking vigorous steps to eradicate the disease. First, that of public health; and second, that of successful animal industry.

Since it is believed by some authorities that tuberculosis is communicable from man to animals, the question of "public health" is of grave importance, especially so in the arid regions of the Southwest, comprising Colorado, Arizona, New Mexico, and part of Texas, because these regions are becoming the "dumping ground" for a large per cent of the tubercular patients of the Northern and Eastern states. The arid regions of the Southwest furnish a large per cent of the cattle that are each year placed in the feed lots in the corn belts of the central states, hence it is evident that, if these states are to furnish in the future the cattle for the Eastern markets, some measures should be taken to eradicate the disease from our Territory. The climatic conditions of the Southwest are excellent to hold the disease in check, but that is not sufficient as something should be done to exterminate the disease after it has secured a foot hold.

SYMPTOMS

It is unfortunate that this disease invades the animal system through so many different avenues, and in most cases has reached a critical stage before any external signs are apparent by which it can be diagnosed, though clinical symptoms cannot be accepted without further proof of the disease. Still, it makes considerable difference which avenue of infection the germs take to produce external symptoms by which it can be diagnosed. It is frequently the case, when infection takes place through the food that the disease makes its first appearance by an acute attack of diarrhea, and when treatment is given for such, the patient seems much improved, when, to our surprise, some unknown cause brings on a second attack, which, in most cases, is likely to be more acute than the first. The patient may continue in this manner for an indefinite length of time, when the characteristic "consumption" begins and the animal finally dies, an emaciated looking object. The progress of the disease is not always so rapid, as the writer has seen animals that were known to have tuberculosis for more than a year and, from all external appearances, were in perfect health. Undoubtedly, such animals are more dangerous to a herd than one in which the external appearance would indicate a disease of this nature. Generally if an animal in the herd is not doing well and becomes emaciated, it is taken from the herd and given extra care until there are signs of improvement. In this way the healthy animals do not come in contact with those that are in any way diseased.

Infection through the organs of respiration is very likely to occur where the animals are closely confined in sheds or stables, where the stalls have been bespattered with the discharges from diseased animals, and allowed to dry; and by sweeping, the dust in the stable is laden with the disease-producing germs. The symptoms of the disease are quite different from those when the germs enter through the food. When the germs enter the air tubes and find convenient lodgement, they form a colony which will grow and in turn spread to all parts of the organs of respiration forming new colonies. This method of growth continues until there is enough foreign matter in the lungs and air passages to cause an irritation, when the animal begins to cough. When this stage is reached, the animal begins to lose flesh, and it makes little difference as to the kind of food given, since genuine consumption has started which, in a short time, ends in the death of the animal.

Since any and all organs of the body are liable to be affected with this malady, the symptoms, therefore, vary more or less, according to the organ affected. If, for instance, the brain be affected, the disease will manifest itself in a variety of nervous symptoms according to the part of the organ affected; that is, the sense of smell, sight, or hearing may be impaired.

To mention all of the many symptoms of tuberculosis, would require more space than this bulletin will afford, but it seems fitting to give a brief description as to how it affects the mammary glands of the cow. When this organ contains tubercular germs, there may or may not be acute inflamation, but as the disease advances, tumors will be formed which will furnish millions of the disease-producing germs.

However, it is unfortunate, that, from any external examination, one is unable to diagnose the case as being caused by the bacilli of tuberculosis or by some other less harmful germ. Since authorities differ on these points, without a microscopical examination, the milk from cows with diseased udders, whether tubercular or not, should first be pasteurized to prevent further spread of the germs.

HOW INFECTION MAY OCCUR

That bovine tuberculosis is an infectious disease is no longer a disputed question, and ways of carrying and spreading the tubercular germs are many. Perhaps the most common vehicle for disseminating the disease is the manner of feeding. The herd, as a rule, is all fed from the same racks and boxes, thus the food, racks, and boxes come in contact with the tubercular animals, and, therefore, they become contaminated with the bacilli. The next animal that comes along partakes of the contaminated food and, as a result, also becomes tubercular. The same may be said of the watering tanks, salt boxes, etc.

Another avenue of infection, especially in young animals, is the milk. At the present time authorities differ, some claiming that the milk of tubercular cows carries the bacilli, while others maintain that the milk does not contain the germs unless the udder be affected: therefore, since authorities differ, it may possibly be safer if the milk of tubercular cows be used at all, that it should first be Pasteurized. Another very common means of spreading the disease, is through the purchase of breeding animals. This means should, perhaps, receive the most attention from the stockmen of this Territory, as each year large numbers of breeding animals are brought in from the neighboring states and placed upon our ranges. Just as long as the buyers make no objection, just so long will the breeders continue, knowingly or unknowingly, to sell infected animals.

EXTENT OF TUBERCULOSIS

Tuberculosis is not confined to any one section or state, but it is found in every state in the Union and every country on the globe. Nor are its ravages confined only to cattle. Very few, if any, of our domesticated animals, are exempt from its attacks; all races of men also are subject to the dreaded disease.

We find from statistics, that among human beings one-seventh of all deaths recorded are due to tuberculosis. This, however, does not include a large per cent of cases of the disease that are cut short by death from other causes.

The following, taken from Bulletin No. 84, of the Wisconsin Experiment Station, will give an idea of the extent of the disease in the United States. "These statistics probably represent more than the actual average of the disease, because in many cases the test has been applied to suspected herds only, and not universally to all cattle in a region."

"New England States.—In Vermont, a large number of tests have been made. Since February, 1895, the State Board of Agriculture has tested 60,000 head, and of these 2,390 or 3.9 per cent. were found to be tubercular.

Several methods of determining the amount of the disease in herds, have been tried in Massachusetts. For a number of years, it has been customary to make a physical inspection of all herds and quarantine all animals suspected of the disease. Of these, 24,685 were tested with tuberculin, from 1894 to 1897, with the result that 12,443, or practically one-half, were adjudged tubercular. In about one-fifth of these, the disease was found to be generalized. From June to December, 1895, tests of entire herds were made upon application of owners, and 4,093 examinations showed 1,080 reactions, or 26.4 per cent. of stock affected.

Of 6,300 cattle tested in Connecticut, 14.2 per cent. reacted.

Middle States.—In 1894, the Tuberculosis Committee of the New York State Board of Health confined part of its work to a given area that was thought to be comparatively free from general infection from other sources, 947 animals were tested, 66 of which were condemned, or 6.9 per cent.

In 1897-8, 1,200 animals were tested. 163 were found to be tubercular, or 18.4 per cent***.

North Central States.—During two years prior to November, 1898, 929 dairy cattle were tested by the Illinois State Board of Live Stock Commissioners, 12 per cent. of which reacted. From May to November, 1899, 3,655 animals were tested, 560 of which reacted, or 15.32 per cent.

In Michigan, about 13 per cent. of the cattle tested by the State Veterinarian have been found to be tubercular***."

TUBERCULIN

* "Tuberculin is a product (an excretion, so to speak) of the tubercle bacillus (the cause of tuberculosis); it is present in the bodies of all tuberculosis patients.

It was prepared artificially, by Dr. Robert Koch, by growing the tubercle bacillus in a nutriment medium, and separating the tuberculin resulting from this process of growth by means of heat to kill the germs and filtering processes to remove the dead organisms."

Tuberculin was first prepared, not as a diagnostic, but as a curative agent in human beings, but experiments showed that for this purpose, it was a failure. However, in cattle, it has proven to be the best diagnostic agent, with the exception of the post-mortem, which is really the only infallible test, but too expensive, to say the least. The use of the tuberculin test, which is based on the conditions that, when a given amount of the solution is injected into the animal which is affected with tuberculosis, except where the disease has reached an advanced stage, produces a temporary fever; that is, the temperature of the animal's body, which is normally about 102° F., varying with conditions, will, in from 8 to 18 hours after the injection of tuberculin, show a rise of two or more degrees F. above the normal temperature. If there be only a rise of 1.5° F., the animal should be considered suspicious and should be isolated and tested again in about six weeks or two months. This rise in temperature is what is known as the reaction and should continue for from 6 to 10 hours or more. Under normal conditions, all animals that react will be found to be tubercular. In rare instances do healthy animals react. As a rule, if a tubercular animal fails to react, it is because the disease has reached such a critical stage that it can usually be detected by a physical examination.

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* Bulletin No, 79, Kansas Agricultural Experiment Station.

HOW TO APPLY THE TUBERCULIN

The general principle underlying all methods, is to obtain the normal temperature of all animals to be tested. This is accomplished by inserting a fever thermometer into the rectum and allowing it to remain for at least two minutes. The temperatures are taken every two hours, beginning at 8 a. m. and continuing until 10 p. m. of the same day, at which time the injection of the tuberculin is made. This is accomplished by the use of a hypodermic syringe. The temperatures are not taken again until 8 a. m., the following day (ten hours after injection) and then are continued every two hours as on the previous day, until 6 p. m., or later if there be any evidence of a rise in temperature.

HOW MUCH TUBERCULIN TO INJECT

The amount of tuberculin injected is commonly given by authorities as 2 c. c. per thousand pounds live weight.

Some authorities suggest that if the animal be suspected of having tuberculosis in an advanced stage, the amount should be increased somewhat, perhaps to 2.5 c. c. per thousand pounds live weight.

WHERE TO INJECT THE TUBERCULIN

It makes little difference where the tuberculin is injected, but experience has taught that the neck or shoulder is the most convenient place to work. It is much easier to hold this part quiet than any other portion of the body.

EXPERIMENTS IN FEEDING THE MILK OF TUBERCULOSIS COWS

*"The use of milk on experiment animals for the purpose of artificially inducing the disease in otherwise healthy individuals is a practical way of putting to the test, some of the theories as to sources of danger. If the milk from tuberculous cows, either taken in the ordinary way, or injected

directly into the circulation can induce tuberculosis, the fact becomes one of no ordinary moment. The significance of the experiment has a two-fold importance.

First:—It enables us to account for many cases of the disease in young cattle. It has been shown by repeated observations that the congenital infection is rare. However, calves but a few months old are frequently found to be infected.

Second:—If milk from tuberculous cows possesses infectious properties, the health and safety of the human family becomes the important part of the question. If feeding the milk to lower animals under ordinary conditions will induce the disease, there is no avoiding the conclusion that it can be induced in the human family under the same conditions. This experiment has been repeated with sufficient frequency, and under conditions to prove the certainty of results beyond question. If milk is contaminated with the bacilli of tuberculosis, it will convey the disease. But under what conditions will the milk be so contaminated, is a question for separate solution. It has been vehemently claimed that only milk from cows with udders in which the disease was localized, was to be regarded as in any sense dangerous.

An exhaustive series of experiments was undertaken by the Trustees of the Massachusetts Society for the Promotion of Agriculture, with a view of gaining light on the question. One of the experiments consisted in feeding twenty-one healthy calves on milk from tuberculous cows. At the conclusion of their experiment they report, 'Of these twenty-one animals, eight, or over thirty-three per cent were shown to be tuberculous. That the cows from which the milk for these feeding experiments was derived were free from tuberculosis of the udder, is shown by the following table (table omitted) of their history, and the results of the post-mortem examination.' They draw the following conclusions:

'The possibility of milk from tuberculous udders containing the infectious elements, is undeniable.'

'With the evidence here presented, it is equally undeniable that milk from diseased cows with no appreciable lesion of the udder may, and not unfrequently does, contain the bacilli of the disease.'

Dr. McKenzie reports that in cases where there were no lesions of the udder, but where tubercular deposits were found in other parts of the body, the milk in forty per cent of the cases proved to be infectious.

This is in accord with the best evidence on this subject and especially does the extensive scientific work of Bang of Copenhagen coincide with these results.

Our Station made experiments on three calves from tuberculous mothers. Two were allowed to take the milk from the mothers. These cows were but slightly affected, the udders to all appearances being free from disease, and no bacilli were detected in the milk when examined under the microscope. Both of these calves developed tuberculosis. A third calf from a tuberculous mother was not allowed to take the mother's milk, but was taken as soon as born and kept on the milk of a cow that had been tested and found to be healthy. This calf never showed reactions when tested with tuberculin. It was slaughtered at the age of three months, and thorough examination failed to detect any sign of disease.

This experiment tends to show that calves from tuberculous mothers are not necessarily tuberculous at birth, but that infection will take place when the udders are healthy and when there is no external evidence of disease."

SOME PRECAUTIONS THAT MAY BE TAKEN

To say what should be done to assist in preventing the spread of tuberculosis in this Territory is an easy matter, but the all important question is, are the ranchmen ready to work for legislative measures that will not only retard the spread of the disease but that will in time eradicate the disease from the Territory?

The old saying, "Prevention is better than a cure," is as true

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* Bulletin No. 29, Iowa Experiment Station.

with tuberculosis as any other disease. Therefore, why should not preventative rather than curative measures be taken? Other states have done so. Why should not New Mexico pass laws requiring that all cattle for breeding purposes, before they enter the Territory, be subjected to the tuberculin test? In this way all breeding stock brought into the Territory in the future would be free from the disease.

If all the cattle in the Territory, especially the breeding stock, be subjected to the tuberculin test each year, and all reacting animals disposed of, it would only be a short time until the cattle of the Territory would be practically free from the disease. This may seem like a costly method, especially so if 10 per cent of a herd should react, but it would be much cheaper to eradicate the disease now than five or ten years hence when 50 per cent of the herd may be tubercular.

As to the extent of tuberculosis in this Territory we are unable to give any definite information, as we have no data regarding tests that may have been made, except the tests made with the Station herd. Since two of the cows in the Station herd that reacted were cows bred and raised in this Territory, it is reasonable to suspect that many others are similarly affected. In the Station herd there were practically 15.8 per cent found to be tubercular. If this represents an average of the Territory, it is gratifying to think that the per cent of deceased stock in this Territory is so low.

TESTS OF THE STATION HERD

The Station herd of cows, consisting of 19 head, were tested November 13th and 14th, 1903, for tuberculosis, with the tuberculin test. The tuberculin for the test was obtained from the Bureau of Animal Husbandry, Washington, D. C. The tuberculin was injected at the rate of 2 c. c. per 1,000 pounds live weight. Part of the herd were again tested December 13th and 14th, 1904.

In both of these tests all precautions possible were taken to avoid any unnatural conditions that might have any effect on the temperature of the animals.

Table I, shows temperature readings for November 13th and 14th, 1903, before and after injection, also the amount of tuberculin injected, the weight, breed, age, and sex and the rise in temperature of each animal.

Table II, shows temperature readings before and after injection for the test made December 13th and 14th, 1904.

From Table I, it will be seen that cows numbers 1, 4, and 29 reacted, showing a difference in temperature, between the maximum before and after injection; for No. 1, of 3.7°, No. 4, of 3.2°, and No. 29, of 1.5° F.

From all external appearance, (see plates Nos. 1 and 3) cows Nos. 1 and 4, showed no external signs of being tubercular, except the coat of cow No. 1 was a little rough,—both animals being fat and of a healthy appearance. The cow No. 29, although only showing a rise in temperature of 1.5° F., yet from all external appearance, (see plate No. 2) one would diagnose her case as in an advanced stage of tuberculosis, as she had a bad cough and was also a badly emaciated looking object. Upon post-mortem examination of cow No. 29 the liver was affected and the lungs, bronchial glands, and pleura were a complete mass of tubercules. (See plate No. 5).

In cow No. 1, upon post-mortem, the disease was found to be local, the lungs only being slightly affected.

Cow No. 4, was not slaughtered at this time, as she was very fat and also heavy in calf, and it was thought that her condition might have something to do with her rise in temperature. But she was isolated and again tested, December 13th and 14th, 1904, when she again reacted and upon post-mortem her lungs were found to be slightly affected. It may be of interest to note that the calf (see plate No. 3) this cow raised, while she was isolated, when tested showed no signs of being tubercular.

ACKNOWLEDGMENTS

The writer is much indebted to Professor J. J. Vernon, of this Station for valuable assistance in making the tests and also in the preparation of this bulletin; and to the Bureau of Animal Husbandry, U. S. Department of Agriculture, Washington, D. C., for the tuberculin used in the test made November 13th and 14th, 1903.

Credit is given in the body of this bulletin for material taken from other publications.

TABLE 1.—TEMPERATURE RECO

Record. Number	BREED.	Sex.	Age of Animals Years	Weight of Animals Lbs.	Amount of Tuberculin injected C. C.	Before Injection.					
						A. M. 8	A. M. 10	M. 12	P. M. 2	P. M. 4	P.
1	Grade Short Horn...	F	11.0	1250	2.5	100.6	100.4	101.1	101.5	102.7	1
4	Short Horn.........	F	5.75	1780	3.0	102.0	102.1	102.6	103.5	103.0	1
5	Hereford...........	F	5.0	1264	2.5	101.6	101.4	101.5	101.2	101.8	1
6	Grade Short Horn...	F	3.5	1090	2.0	101.1	101.6	101.1	100.9	101.7	1
7	Grade Jersey........	F	3.0	1046	2.0	101.6	101.0	100.8	101.2	101.5	1
8	Grade Short Horn...	F	1.75	984	1.5	102.4	101.6	101.1	102.7	103.0	1
9	Grade Jersey	F	U	1146	2.25	102.2	101.4	101.4	102.1	102.0	1
10	Jersey........ ..	F	2.5	690	1.5	101.6	101.8	101.5	102.3	102.0	1
11	Grade Guernsey.....	F	U	1074	2.0	101.2	101.4	101.3	101.5	101.5	1
12	Grade Jersey........	F	1.0	744	1.5	101.6	101.5	101.9	102.3	102.1	1
13	Grade Hereford....	F	1.5	690	1.5	101.4	101.0	100.7	101.6	101.4	1
15	Grade Short Horn...	F	1.3	674	1.0	101.2	101.6	101.6	101.2	101.8	1
19	Grade Jersey........	F	U	1052	2.0	102.0	102.0	102.5	102.2	102.6	1
20	Grade Jersey........	F	U	834	2.0	101.0	101.0	101.2	101.3	101	
21	Grade Jersey.......	F	U	1092	2.5	102.0	102.0	101.8	101.4	101	
22	Grade Jersey...	F	U	910	2.0	102.0	101.4	101.3	101.2	101	
29	Grade Short Horn...	F	U	900	2.0	98.3	100.6	102.4	104.6	104.9	1
0	Jersey...............	F	5.0	1100	2.0	100.8	100.4	101.7	102.0	102.1	1
68155	Jersey...............	M	1.25	625	1.5	102.4	102.2	101.6	101.3	102.0	1

Note.—F=Female
M=Male
U=Unknown

TABLE 2.—TEMPERATURE RE

Record Number.	BREED.	Sex.	Age of Animals Years	Weight of Animals Lbs.	Amount of Tuberculin Injected C. C.	Before Injection.					
						A. M. 8	A. M. 10	M. 12	P. M. 2	P. M. 4	P·
4	Short Horn....	F	6.75	... .	3.0	100.6	100.9	101.3	101.4	102.7	1
17	Grade Jersey.. ...	F	1.3	... ...	2.25	100.1	101.3	102.1	102.3	102.5	1
23	Jersey......	F	.75	....	1.5	101.2	102.4	102.3	101.8	103.1	1
24	Short Horn....	F	.75	. ....	1.75	101.4	102.5	102.4	102.1	102.2	1
28	Grade Jersey.......	F	U	....	2.25	101.1	101.2	102.2	102.4	103.2	1
68155	Jersey...............	M	2.3	....	2.5	101.1	101.2	100.8	101.3	101.6	1

Note. -F -Female
M -Male
U- Unknown

)S OF STATION HERD—1903.

		After Injection.								Maximum		
P. M. 8	P. M. 10	A. M. 8	A M. 10	M. 12	P. M. 2	P. M. 4	P M. 6	P M 8	P. M 10	Before	After	Difference.
101.3	101.2	102.7	105.4	106.4	106.0	105.6	103.2	102.2	101.6	102.7	106.4	3.7
102.8	102.5	105.6	107.2	106.1	106.2	105.4	105.8	104.5	103.9	104.0	107.2	3.2
101.5	101.2	101.2	101.4	101.2	101.6	101.4	100.7	....	...	101.8	101.6	—.2
101.8	101.6	101.3	102.4	101.1	101.5	101.6	101.6	....	....	102.0	102.4	.4
102.0	102.1	101.5	100.9	101.2	101.3	101.4	102.4	....	.. ....	102.2	102.4	.2
103.0	102.8	102.2	101.5	102.0	101.9	102.7	103.9	....	....	103.4	103.9	.5
102.3	102.2	101.4	101.7	101.6	101.8	102.4	102.1	.. ....	....	102.9	102.4	—.5
101.4	101.2	100.9	101.0	101.4	101.8	102.8	101.8	.. ...	.. ....	102.3	102.8	.5
101.7	100.0	100.8	101.0	100.6	100.9	101.2	101.7	....	.... ..	101.9	101.7	—.2
103.0	102.4	101.7	101.7	101.9	102.4	102.4	103.2	.. ....	....	103.5	103.2	—.3
101.9	102.0	101.5	101.4	101.1	101.4	101.2	102.8	.. ....	....	102.5	102.8	.3
102.0	102.4	101.4	101.3	101.2	101.7	102.0	102.4	....	....	102.4	102.4	.0
103.1	102.2	101.8	101.8	102.0	102.3	103.0	103.2	....	......	103.2	103.2	.0
[illegible]	102.0	101.0	101.9	101.1	101.7	101.4	102.2	......	....	102.0	102.2	.2
[illegible]	101.8	101.1	101.4	101.2	101.4	102.0	102.3	... ...	....	102.8	102.3	—.5
[illegible]	101.6	101.7	101.1	100.8	101.0	101.6	102.5	....	....	102.9	102.5	—.4
101.1	101.5	101.8	103.8	106.4	106.4	105.1	102.6	100.0	99.8	104.9	106.4	1.5
102.4	101.6	101.6	101.4	101.7	102.6	102.2	102.2	....	....	102.4	102.6	.2
102.1	102.4	101.9	101.0	101.4	101.3	102.4	102.7	.. ....	....	103.1	102.7	—.4

RDS OF STATION HERD—1904.

		After Injection.								Maximum		
P. M. 8	P. M. 10	A. M. 8	A. M. 10	M. 12	P. M. 2	P. M. 4	P. M. 6	P. M. 8	P. M. 10	Before	After	Difference.
101.8	102.0	103.6	104.0	106.0	105.8	105.7	105.7	104.1	103.9	102.7	106.0	3.3
102.3	102.8	101.6	101.4	101.0	102.0	102.1	....	... ...	....	102.8	102.1	— .7
102.0	101.9	101.0	102.0	101.6	101.9	101.7	....	....	... .	103.1	102.0	—1.1
102.6	102.6	101.4	102.0	102.0	102.1	102.5	....	....	....	102.6	102.5	— .1
101.8	102.1	102.0	100.8	101.6	102.3	102.0	....	....	....	103.2	102.3	— .9
102.6	102.4	101.2	101.8	101.1	101.9	101.5	... .	....	....	102.6	101.9	— .7

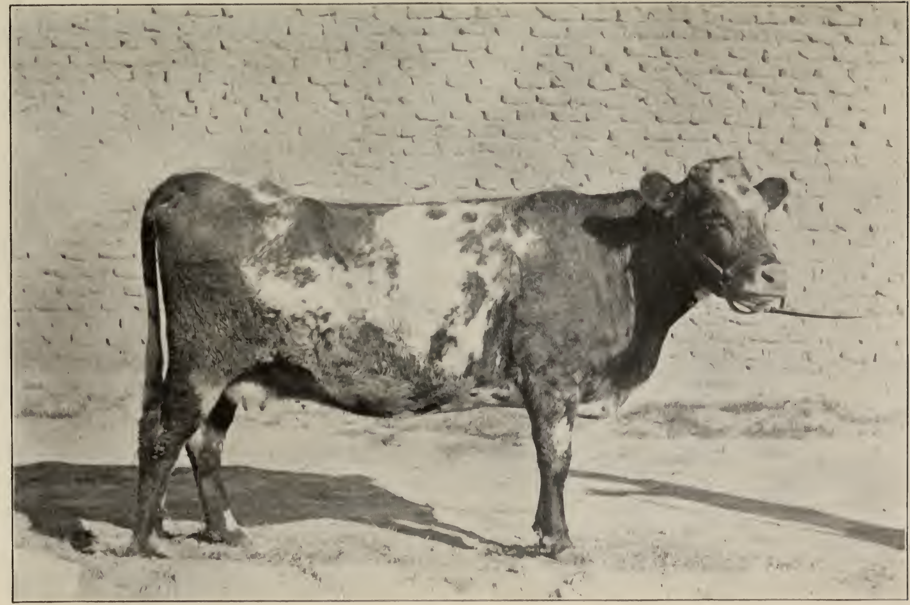

Plate No. 1—Cow No. 1.

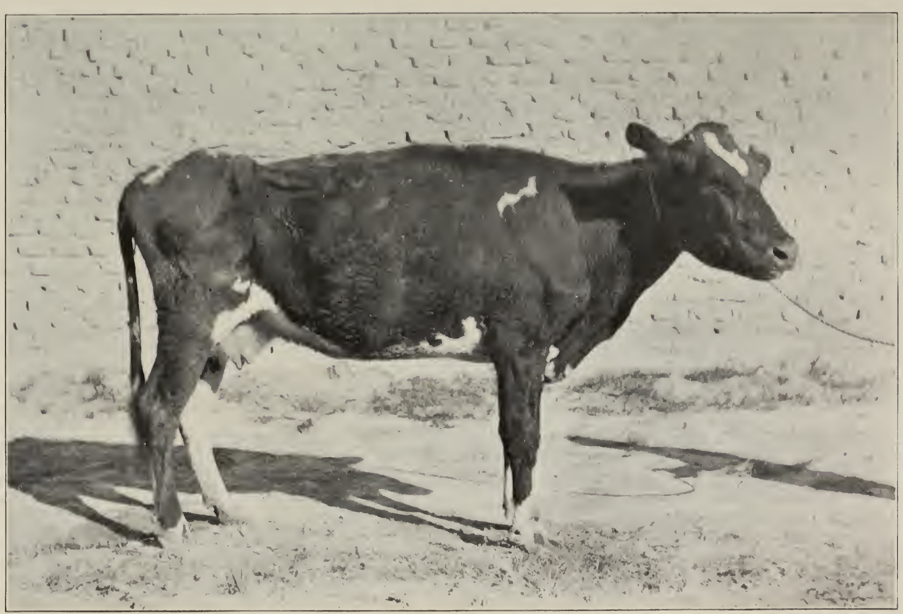

Plate No. 2—Side View of Cow No. 29.

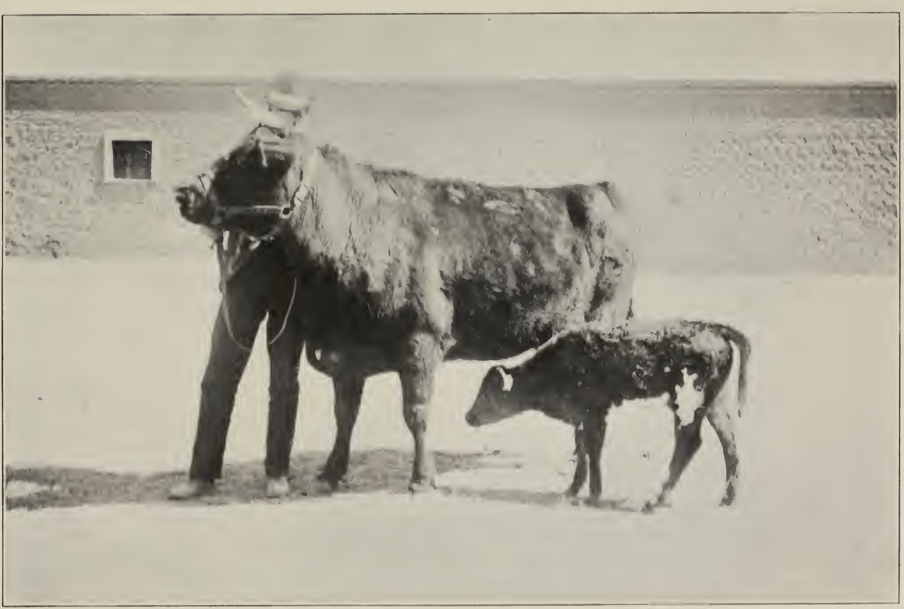

Plate No. 3—Cow No. 4 and Calf.

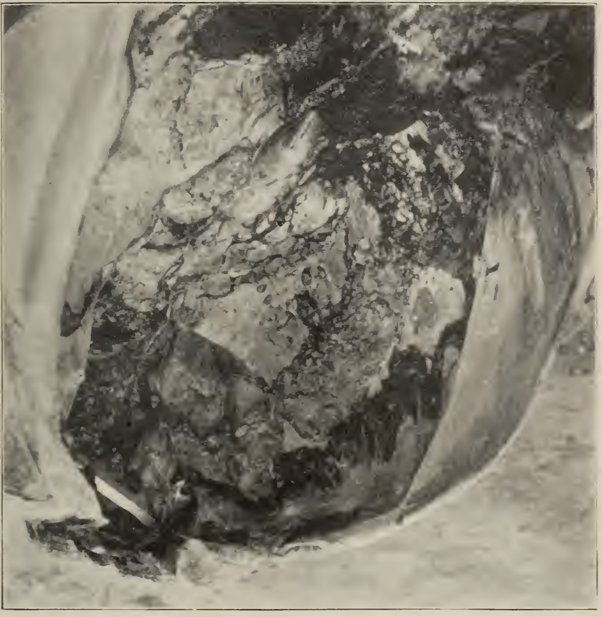

Plate No. 5—Internal View of Cow No. 29.

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